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ERRATA

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

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Page 604, Table VII, column 6, *for* " Per cent itrogen " *read* " Per cent nitrogen ".
Page 636, line 5, *for* " resent " *read* " present ".
Page 636, line 6, *for* " emale " *read* " female ".
Page 637, last but one line *for* " last " *read* " lasts ".

VOL. IX, PART V, OCTOBER 1939

Plate XXXV, explanation of Fig. 10*c*, *for* ' Schlerortia ' *read* ' Sclerotia '.
Plate XXXVII, letterpress under Fig. 1, line 3, *for* ' inocuation ' *read* ' inoculation '.

ORIGINAL ARTICLES

POISONOUS PLANTS OF INDIA

BY

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Introduction

IT is admitted on all sides that the country in which we live is a veritable emporium of drugs containing powerful active principles. Nearly three-fourths of the drugs mentioned in the British and other pharmacopœias grow in a state of nature here and the others can be easily grown. The country has vast resources so far as medicinal plants are concerned, and it abounds in many kinds of perfumes and spices which are known all over the world. India possesses climatic conditions varying from the torrid to the frigid zone. It embraces vast tracts of tropical plains, temperate hills and valleys, irrigated soil, and moist and dry climates. It has in fact been described as an epitome of the climates, seasons and soils of the British Empire. No wonder then that the plants containing active and medicinal principles grow abundantly within its bounds. More than 2,000 such plants have been enumerated in the literature of the indigenous systems of medicine which are alleged to have medicinal properties of some description or other and have been used in indigenous medicine in some form or other. The majority of these plants have not yet been fully investigated.

Many among them are said to contain powerful and toxic principles. If introduced into the body of an animal in relatively small quantities, they will act deleteriously and may cause serious impairment of bodily functions or even death. They injure the basic life principle, the protoplasm of the cells of which the animal body is built up, by virtue of their chemical constituents whose nature may be known or unknown. Such a definition of poisonous plants would exclude plants which act entirely in a mechanical way, such as certain grasses notably *Stipa*, *Aristida* and *Heteropogon*, whose 'seeds' may pierce the skin and produce abscesses or make their way into the salivary ducts of animals and do serious injury; nor would it be desirable to include spiniferous plants which do considerable harm to man and animals. On the other hand, it will include some foodstuffs or fodder plants which may

become deleterious under certain conditions. The harmful effects produced by chemical substances contained may be immediate or cumulative, i.e. they may appear after a period of time when the poison has had time to accumulate in the body in sufficient concentration to produce its deleterious effect after repeated administration. All such plants come under the category of poisonous plants.

Chemical constituents of plants responsible for toxic effects

(1) The first class of these substances are vegetable bases which include amines and alkaloids. As a class these bodies are characterized by their profound physiological action and in many cases their intensely poisonous nature. Some of the amines give a foetid odour to some weeds, and to some mushrooms their poisonous characters. The alkaloids as a rule give a bitter taste to a plant in which they naturally occur, and that in itself is frequently a sufficient protection against livestock eating it, except in unusual cases of hunger. A considerable number of medicinal drugs owe their curative properties to these principles. The grasses as a rule do not contain these bases but they do occur in many of the other families. Examples of alkaloids are strychnine from nux-vomica, aconitine from aconites, atropine and allied alkaloids from belladonna, nicotine from tobacco, morphine from poppy, etc.

(2) Another class of poisonous substances are represented by glucosides which form a large group and are much wider in occurrence than alkaloids. Many are non-toxic but quite a large number of them are intensely poisonous. They have generally a bitter taste and occur in many of the plant extracts used in medicine. Well-known examples of toxic glucosides are those occurring in the Oleander family (*Apocynaceæ*) and *Digitalis* (*Scrophulariaceæ*).

A group of glucosides which are important from the point of view of livestock-poisoning is represented by the cyanogenetic glucosides which contain hydrocyanic acid bound up in them ; this is liberated by enzymes mostly occurring in the same plants. As the name implies they split in the animal body, liberating sufficient quantities of hydrocyanic acid to produce fatal results. The well-known representative of this class is one occurring in bitter almonds and known as amygdalin. They also occur in a number of grasses and members of the pea and rose families, etc.

Another group of glucosides, when agitated with water, produce soapy foam and to these the name of saponins is given. In the vegetable kingdom they occur in at least 400 plants belonging to 50 different families. They are particularly poisonous to certain lower animals, for example fishes, frogs, insects, etc. The fish are killed by these bodies in such high dilutions as 1 in 200,000 or more. In higher animals, when taken by mouth, they produce gastro-intestinal irritation, vomiting and diarrhœa. In cold-blooded animals, such as fishes, they produce paralysis of the respiratory organs. They produce hæmolysis when they come in contact with blood and have an acrid taste. Common examples containing saponins are soap-nut, soap-bark and soap-root.

(3) The third group of poisons is furnished by essential or volatile oils which give characteristic odours to plants. These bodies are characterized

by their insecticidal and insect-repellent properties, while in man and livestock they produce toxic effects by gastro-intestinal irritation. Common examples are those occurring in eucalyptus, in absinth which produces convulsions by its action on the nervous system, the pine family and that produced from mustard seed by the action of an enzyme, etc. Cattle do not as a rule feed on the plants containing the toxic essential oils.

(4) The fourth group of toxic substances are known as toxalbumins which occur in castor, croton and abrus seeds. These are essentially blood poisons and are responsible for frequent losses among livestock. Animals can, however, become immune to these bodies if they are given in small and gradually increasing doses, but the immunity is of a specific nature, i.e. against that particular toxalbumin and not against others.

(5) Lastly there are groups of substances called resins such as those occurring in podophyllum, bitters such as are found in wild members of the cucumber family, for example colocynth, phenolic compounds such as those found in many members of the cashew family. Other highly toxic principles are andromedotoxin occurring in many members of the rhododendron family, toxic oils such as croton oil, picrotoxin, a convulsant poison found in *Anamirta cocculus* (Linn.) W. and A. (poison berry) which is a climbing shrub of the Indian forests, and neutral principles, organic acids and their salts, etc. All these have been responsible for poisoning in man and animals.

Factors affecting toxicity

The amount of poisonous substances present in plants is dependent upon several factors, for example the nature of the soil, the climate, the season, the stage of growth of a plant, the nature and intensity of light, cultivation, etc. Fresh, green plants may be poisonous and in a dried condition the toxicity may be lost, for example in buttercups and other plants which have volatile active principles. Toxicity may be lost by cultivation as in the case of gourds, while the toxic principles in cinchona and oleander do not deteriorate through cultivation. The stage of growth of a plant is perhaps the most important factor in determining its toxicity.

Susceptibility of animals to plants varies enormously. Rabbits are insensitive to the atropine group and birds stand large doses of strychnine. Young mammals are generally more susceptible than old. The condition of the animal, personal idiosyncracy, tolerance and immunity also play a part in determining the degree of susceptibility to the poison.

To endeavour to compass within this paper even a comprehensive bird's eye view of poisonous plants of India would be impossible. Our object is to put before the reader as briefly as possible the importance of this work from its economic and toxicological aspects in relation to man and lower animals.

Toxicological aspects

I. Cryptogams (the flowerless plants)

The toxicological aspects of the cryptogams are very little known so far as India is concerned and we will make only brief reference to them.

(a) *Bacteria*

The bacteria are among the simplest form of plant life and are met with universally. The majority of them are harmless but some are injurious to man and animals. They produce deleterious effects in two ways: Firstly as parasites, when they derive their nourishment from living animals and many of them produce, within the body, toxins which are harmful. Secondly many saprophytic bacteria produce poisonous substances, especially such as those occurring in putrid flesh, fish and other decaying organic matter. It is not our intention to include them in this paper as, although they belong to the vegetable kingdom, they are a class by themselves and do not come under the category of poisonous plants.

(b) *Algæ*

The algæ that cause poisoning are mostly those which are found in stagnant waters. The normally offensive odour may be sufficient to indicate their presence, but only a microscopic examination can determine just what the forms of algæ present may be. Blue-green algæ, as a group, are perhaps the most pronounced in their toxic effect. Prof. Parker and other workers have shown that when odours in water are pronounced, the microscopic, organisms are present in considerable numbers. According to him, of the organisms which produce objectionable and deleterious qualities in waters, the microscopic ones are the more important and very few cases have been observed in which really serious trouble in water supplies could be attributed directly to the growth of larger plants. In any study of the algæ from this point of view, however, account must be taken of the products of decomposition by the associated bacteria since poisoning may be produced by the toxins produced by bacteria rather than by the algæ.

Certain algæ, such as *Microcystis flos-aquæ* (Wittr.) Kirch., *Aphanizomenon flos-aquæ* (Linn.) Ralfs. and species of *Anabæna*, etc. form on the surface of water what is generally called water bloom. The presence of water bloom on the surface of lakes, ponds, and other open sheets of water is distasteful to bathers and obnoxious to those living in the vicinity. Livestock compelled to drink water containing water bloom are reported to have been poisoned. In Minnesota, (U. S. A.) during recent years, horses, cattle, sheep, and turkeys have died in large numbers on the shores of lakes where water bloom is present. All the above-mentioned algæ forming water bloom have been recorded in various parts of India but no work has been done in connexion with their toxic effects. According to Dr Bhardawaja of the Benares Hindu University, water blooms containing these species occur commonly on the surface of many temple tanks in different parts of India. Of the other possibly harmful algæ may be mentioned species of *Nodularia*, *Clathrocystis*, *Nostoc*, *Oscillatoria*, *Pandorina*, and *Volvox* when present in large numbers.

The question of growth of algæ in water reservoirs leads us to a very important public health problem. Although in India very little information is available about the contamination of the water supplies with the group of toxic algæ, we cannot pass over this important question without drawing attention to the importance of checking their growth in the reservoirs of water

supplies. One of the essentials of the algal growth is light. Their growth may, therefore, be prevented, or at any rate considerably reduced, by covering up the reservoirs and cutting off sunlight. Unfortunately, most of the reservoirs for the supply of water to both animals and man in India are generally not covered and are often largely contaminated with algal growth. The removal of organic matter by keeping the source of water supply in as pure a state as possible will no doubt keep down the algal growth but it must be understood that nearly all water contains sufficient organic matter for the growth of algæ, especially the water coming from water-sheds. Growth of algæ can also be successfully prevented by the addition of copper sulphate in dilutions of one in five millions or even higher. This does not render the water deleterious to man and animals.

The problem of toxic algæ is important and deserves the attention of workers in this field.

(c) *Fungi*

i. Some fungi live on the skin and mucous membranes of man and animals and cause various diseases, e.g. ringworm, thrush, etc.

ii. There are others which attack foodstuffs and among these may be mentioned: (1) *Smuts.* Many of these are destructive parasites which invade plants of vital economic importance, such as oats, wheat, millet and other cereals. Some are supposed to be poisonous if taken in large quantities, and others are said to produce irritation of the mucous memberane. There is difference of opinion with regard to the injurious effects produced by particular kinds of smut and hardly any authentic information is available regarding those occurring in India. The subject deserves careful investigation by mycologists. (2) *Rusts.* Annual recurrence of the outbreaks of rust attacks of cereals in India, especially those attacking wheat, is of great economic importance to the country. These, especially the uredo stage, produce inflammation of the mucous membrane of the mouth and nose. The dust coming from the infested straw when the grain is thrashed is stated to cause serious disturbances of the respiratory tract. Very little information is available about the Indian strains. (3) *Ergot*, which grows on rye, is a well known example of a fungus which produces highly poisonous substances, but there is no evidence of its occurrence in India. (4) The poisonous nature of the seeds of darnel (*Lolium temulentum* Linn.), a grass and annual weed of cultivation, especially up-country, is believed to be due to a fungus, and cases of poisoning due to admixture of the seeds with wheat grains are not infrequently reported in India and abroad. Cases of death among livestock have also been reported. The animals should not be allowed to feed on the plants when seeds are formed.

(5) Very variable data are available as regards the poisonous effects of mouldy foodstuffs in India but there appears to be little doubt that the presence of certain species may occasionally produce harmful effects in man and animals. Species of *Mucor*, *Aspergillus*, *Penicillium* and *Fusarium*, etc. deserve special investigation in this connexion. It appears, however, that there is an appreciable difference in the susceptibility of different species of animals to the effects of mouldy foodstuffs. In general it has been stated

that horses, dogs and pigs are more susceptible than ruminants and poultry, while in other animals the case may be the reverse. Very little information is available about the toxicity of moulds occurring in India and the problem requires a thorough investigation because of its great economic importance. In the meantime it would be safer to consider all fungus-infected foodstuffs as deleterious. Acute poisoning with the moulds is rarely met with and if they are taken in small quantities there is hardly any danger. The practice of throwing away mouldy pickles and other edible substances is no doubt a step in the right direction.

iii. The third group of the poisonous fungi belong to the mushroom class. A number of these are edible and many occurring in India are indiscriminately eaten. Cases of fungus poisoning, therefore, are not infrequently met with, particularly in the hills. Unfortunately very little information is available about the poisonous fungi growing in this country and in spite of cases of poisoning, little attention has been paid to the subject.

Stropharia semiglobata (Batsch) Quel. from Khasia hills, *Hypholoma fasiculare* (Huds.) Fr. from Darjeeling and Simla and *Lactarius vellereus* Fr. from Sikkim are regarded as poisonous. There is also evidence on record that there exists in Bengal a fungus which closely resembles an edible form but which contains amanitine or muscarine, the poisonous principle of the foreign *Amanita muscaria* Pers. Recently two mushrooms were sent to us from Kumaon as being poisonous. These were identified as *Collybia* and *Cantharellus*. There are probably many more poisonous species than have really been incriminated as poisons, but on the whole their number may be small and indeed if properly cooked only a few are dangerous. If washed in water and macerated in vinegar before cooking, and if eaten with plenty of bread there is almost no danger in most cases. The safest method, however, is to learn to recognize the edible species and never to eat a fungus until its identity is certain.

Some of the foreign poisonous fungi, e.g. *Lepiota cristata* Quel., *Volvaria gloicephala* Gill., *Amanita muscaria* Pers. and *Amanita phalloides* Secr. are well known. The last-mentioned is responsible for perhaps 90 per cent of the deaths caused by fungus poisoning in Europe, Great Britain, and U. S. A. During the world war, when food scarcity became acute in Germany and Austria, poisoning from fungi appreciably increased. According to Ford there are four main types of mushroom intoxication: (1) Gastro-intestinal in which the attack ceases when the stomach is emptied. (2) General catharsis which is painless. (3) Violent vomiting and pain but no involvement outside the gastro-intestinal tract. (4) Choleriform type producing widespread degeneration of cells.

(*d*) *Lichens*

Very little is known about these symbiotic organisms which consist of algal cells enveloped by the mycelium of the fungus forming a felted mass. Although this group is not to be regarded as a serious menace to livestock, cases of poisoning due to *Parmelia* and *Cretraria* species, etc. are mentioned in foreign literature. *Parmelia molliuscula* has been said to affect sheep and cattle, producing lack of coordination of the hind limbs. In more severe cases

the animal lies down and is unable to move either its front or hind limbs. Little or no information is available about lichens in India and even their systematic botany has not been sufficiently worked out.

(*e*) *Bryophyta (liverworts and mosses)*

This is the least-known group of plants from the view-point of poisoning and we have, therefore, nothing to say about it.

(*f*) *Pteridophyta (vascular cryptogams)*

This group includes ferns and allied plants, and unfortunately little or no work has been done in India with regard to their toxicity. Greshoff and others have reported the presence of hydrocyanic acid in a number of ferns, especially when young. References to the supposed poisonous properties of the bracken (*Pteris aquilina*) have appeared in the literature for a long time, and Stockman in Great Britain showed that it is poisonous to cattle when eaten in considerable quantities. The plant is found in India. *Aspidium filix-mas*, the male fern, is suspected of being poisonous. The roots are used in medicine and large quantities of it produce hæmorrhagic gastro-enteritis, tremors, weakness, stupor, coma, acute nephritis, and cystitis. Six drachms of the oleoresin have proved fatal in man and three ounces in the cow. This fern is not found in India, but since there are several other foreign species of *Aspidium* which are also suspected of being poisonous it may be worth while to examine Indian representatives of these plants. Some foreign species of *Osmunda*, *Davallia* and *Adiantum* are also suspected of being poisonous, but nothing is known of Indian representatives of these ferns.

Some of the foreign species of *Equisetum* (horsetail) have long been recognized in foreign countries as injurious to cattle and horses. They produce an intoxication in which the animals stagger about and wander aimlessly. There is no information available in India with regard to the Indian horsetail, *Equisetum arvense*, but several European and American workers are convinced that it is definitely poisonous to horses, while others hold a contrary opinion. This plant grows commonly in certain places in India where it might be a menace to livestock.

II. Phanerogams (the flowering plants)

After having given a very brief survey regarding the toxicological aspects of the Cryptogamic flora we will now take up the Phanerogams. Economically this is the most important group both for man and animals from the point of view of everyday necessities of life, *e.g.*, food, medicines, etc. It is probably on account of this that more information is available with regard to this group.

From a toxicological point of view the Phanerogams may be divided into two main groups.

i. *Plants poisonous to man and livestock*

(*a*) *Poisonous to man.*—Primitive man in his quest for food must have come across plants containing poisonous principles by accident and by experience must soon have learned to avoid them. He even made use of them

for the purpose of fighting against his enemies and for procuring his food by killing animals with them. Many of the forest tribesmen of India, numbering 18 millions, use these poisonous plants to fight their enemies and to kill game. Among the civilized, poisoning by accident, ignorance or intention is met with even at the present time. On the whole, our knowledge is fairly well advanced so far as the relationship of poisonous plants to mankind is concerned.

Some poisonous plants have been used for criminal purposes, but the majority of them are used as medicinal agents for the amelioration of human suffer ng. It is well known that many plants, that are harmful to life in large quantities, produce remarkably beneficial effects in small regulated doses. There is no doubt that in a country like India with a luxuriant flora, cases of poisoning with unknown plants do occur, but these are not common. From the economic point of view, the abundance of this group of plants in our midst is of very great importance inasmuch as it provides us with medicinal agents of every description, not only sufficient for our own use but also for purposes of export.

(*b*) *Poisonous to livestock*.—The second important aspect of these plants is in connexion with poisoning of livestock and here, as compared with other countries, our knowledge is very meagre. In India, there are hundreds of plants that are intimately connected with the food supply of roughly 220 millions of the bovine population out of a total of about 730 millions in the whole world. The fodder supply for this livestock amounts to at least 33 million maunds daily (excluding the concentrates that are in use). Even in its present unsatisfactory condition, the cattle industry contributes approximately 10,000 million rupees to the annual agricultural income of 20,000 million rupees of this vast country. Unfortunately no figures are available of the loss suffered through poisoning with plants in India, but we believe these must be enormous. It may be interesting here to give the example of two states, Montana and Colorado in the United States of America which may give us some idea of the possible damage. In that area it has been computed that the loss caused to the livestock industry by plant poisoning is in the neighbourhood of 200 million dollars annually. This is a very large figure considering that the size and extent of these states, as compared with India, is less than one-sixth, and also considering the fact that the knowledge of the poisonous plants there is well advanced and preventive measures are in vogue.

Though the number of plants which have markedly poisonous properties is perhaps small compared with the total species included in the Indian flora, there are many which are of common occurrence and which no doubt produce serious losses by death or illness among sheep, cattle and other domestic animals. The toxic effects produced may be indicated by reduction in the yield of milk, the milk may become unpalatable through excretion in it of toxic products, or it may even become poisonous (e.g. in the case of nux-vomica) and thus become unfit for consumption. The flesh of the poisoned animals, with the exception of the part where the poison has been introduced (e.g., by arrow wound) generally remains edible, though the viscera, especially the excretory organs, have to be discarded.

It may be stated here that animals do not instinctively select toxic plants as forage, that all classes of livestock are not necessarily equally susceptible to the same poisonous plants, that not all poisonous plants are dangerous from their initial appearance up to maturity and that in some cases the animals do acquire a depraved appetite for harmful plants, especially when the fodder supply is scarce, a condition which is of frequent occurrence in many parts of India. The losses in many cases may be avoided by increasing our knowledge about these plants by a systematic study and by working out practical preventive measures.

Prevention.—The question arises as to what should be done to prevent poisoning by plants. The adage 'prevention is better than cure' is applicable to the problem of plant poisoning with just as much force as in other spheres. Often cases are brought to notice when the symptoms have developed and the poison has already circulated in the blood stream and done irreparable damage to the system. Increased knowledge of the poisonous plants is the first step in this direction and this is sure to have an effect in decreasing fatalities among human beings and livestock. Keeping the animals away as far as possible from dangerous areas and exercising special care during periods of drought are likely to decrease the mortality amongst livestock. Eradication of poisonous plants is a difficult matter, involving an enormous amount of labour and capital, but wherever and whenever possible it should be resorted to. This depends upon the habits of the particular plant. Such plants may be annual, biennial or perennial herbs, or shrubs or trees. Annuals complete their life-cycle within one year; these should be pulled out or dug out before seeding. Biennials require two years to complete their life-cycle, growing one year, and flowering and fruiting in the second; these may be dealt with as the annuals. Perennial herbs last several years, not perishing normally after once flowering and fruiting; the above-ground portion dies each year, the root persisting. These are propagated both by the seeds and by the underground organs, such as tubers, rootstocks, bulbs, etc. and may be dug out if not deeply rooted. Shrubs are woody perennials and should be cut down or dug out. Cutting down of lower branches of trees within the reach of animals or children is advocated.

The indiscriminate importation of ornamental plants has recently increased the number of poisonous plants in India. Some of these do not find much competition in their adopted home and are spreading or are likely to spread in this country at an enormously rapid pace. The time perhaps is not yet ripe to agitate for a law prohibiting the importation of poisonous plants for gardens or to take measures to forbid the cultivation of those already introduced, but sooner or later it may have to be considered. In the meantime an appeal may be made to the good sense of the people to limit such practices as far as possible. The cuttings should not be disposed of in such a way as to be accessible to livestock.

The foodstuff dealers should make sure that adulteration is not practised either with poisonous plants or with plants whose properties are doubtful. Recent work in connexion with the causation of epidemic dropsy at the School of Tropical Medicine, has shown that in some epidemics mustard

oil adulterated with *katakar* oil from the seeds of *Argemone mexicana* Linn., the mexican poppy or *shialkata*, was the cause of the outbreak. Experimental work on human volunteers showed that food cooked in oil containing known quantities of argemone oil produced symptoms of gastro-intestinal irritation, oedema and cardiac involvement closely resembling those found in epidemic dropsy. The active principle present in this oil has a cumulative effect, and provided a sufficient quantity of the oil is consumed, symptoms appear even though the consumption of the argemone oil or incriminated mustard oil is stopped. From the evidence available it is clear that the adulteration of mustard oil with argemone oil may or may not be intentional on the part of those who grow mustard seeds or those who express or sell the oil. The plant *Argemone mexicana* grows abundantly and its seeds bear a superficial resemblance to the mustard seeds.

Food poisons.—In connexion with this group, the question of food poisons is of special significance and it will not be out of place to cite a few instances.

1. *Khesari dal*, *Lathyrus sativus* Linn., an important article of diet in man and animals, has been responsible for a large number of cases of poisoning under certain conditions in man, cattle, sheep, pigs, horses, pigeons, ducks, etc. Examples of lathyrism in man in the form of spastic paralysis are commonly seen every day in the streets of Calcutta and its toxic effects in horses and cattle are well known. Moderate amounts of this pulse can be taken with impunity. It is only if large amounts are taken, especially to the exclusion of other fodders or foods, that the untoward symptoms develop.

2. Grasses (*Gramineae*) form an important part of the food of animals. Some of these develop dangerously large quantities of hydrocyanic acid under certain climatic and soil conditions, especially at times of drought or when the plants are wilting, stunted or young. Unfortunately our knowledge of Indian grasses in this connexion is meagre and it is not possible to estimate the losses in livestock from this source. From some of the recent work done it would appear that quite a number of these grasses may be dangerous under conditions that still need to be investigated in India. The examples are *jowar* (*Sorghum vulgare* Pers.), the Indian millet, which is largely cultivated in this country as fodder for cattle and also for human food. It has caused serious outbreaks of poisoning among livestock when wilted or stunted under drought conditions. *Sorghum halepense* Pers., a tall perennial grass with creeping rhizomes and numerous suckers, known as Johnson grass, grows all over India under the name of *baru* in Hindi and *kala-mucha* in Bengali. It has been responsible for serious losses among livestock during recent years in the N.-W. F. Province where it is known as *dadam*. It has been stated that the amount of hydrocyanic acid in these plants decreases with the age of the plant but never entirely disappears. The points to be remembered about these grasses are that they are dangerous during wilting and under conditions of drought, that younger and more succulent ones are often more likely to contain lethal doses of hydrocyanic acid and, that, if well dried, these plants are generally not dangerous. The toxicity in the case of cyanogenetic compounds depends on the quantities of hydrocyanic acid liberated, and according to the amount and speed at which they are eaten. Often such large quantities are given that the animal

will die before any veterinary aid can be given. The only remedy is prevention. The problem of poisonous grasses is of great economic importance in certain parts of India where rains often fail and drought conditions prevail. In the recent famine in the Hissar district of the Punjab there is little doubt that in addition to ravages caused by scarcity of food, the livestock must have suffered enormously from this source.

(3) The linseed plant, *Linum usitatissimum* Linn., contains a cyanogenetic glucoside, the maximum amount of which is reached very early in the development of the plant and finally disappears, except in the seed, which still contains small quantities. An oil is expressed from the seeds and the remaining cakes are used to feed livestock. Cases of poisoning have been frequently reported amongst animals feeding on this plant. It is unsafe to feed the cattle on the immature plant, especially when it is wilted. The cake after extraction of the oil should be treated with boiling water to destroy the enzyme responsible for liberating hydrocyanic acid from the glucoside, and should not be soaked in cold water overnight. It should be given only in small quantities at a time.

(5) The mustard cake which is fed to cattle after the extraction of oil may produce chronic irritant poisoning, colic, lassitude, etc., if fed in large amounts and over prolonged periods, on account of the liberation of an essential oil by the action of an enzyme on the glucoside contained therein. The danger seems to be less in the case of *sarson* seeds than in the case of *rai* or black mustard. If boiling water is poured over the crushed cakes the enzymes are destroyed and the cakes become safe.

(6) Several members of the cucumber family (*Cucurbitaceae*) are edible but bitter varieties are occasionally met with. The latter have a strong purgative action and should be discarded. Incidentally it may be remarked that most of the wild members of the family are toxic. Colocynth which is a powerful intestinal irritant is a familiar example. The bitter members of this family have more or less a similar action.

(7) The leaf-blades of rhubarb (*Rheum* sp.) may give rise to nausea, violent vomiting, purging and abortion on account of having a high percentage of oxalic acid or oxalates in them, while no such cases have been reported from eating the leaf-stalk. The fresh leaves of beet-root (*Beta* sp.) have also produced poisoning in livestock on account of the presence of oxalates.

(8) The potato, *Solanum tuberosum* Linn., when sprouting, produces dangerously large quantities of the toxic alkaloid, solanine, and must be thrown away.

(9) Certain plants, such as buck-wheat (*Fagopyrum esculentum* Moench) which is largely cultivated for human and animal consumption, under certain conditions not yet fully understood, become toxic and give rise to inflammatory swellings of the face, eyelids and ears.

ii. Plants poisonous to insects and fishes

(*a*) *Insecticidal and insect repellent plants.*—The second group of these plants are those which are poisonous to insects and pests which do incalculable harm to man in many ways. The finding of cheap insecticides for

the diverse needs of agriculture, destruction of household pests, prevention of vectors of such diseases as malaria and many others borne by insects is a very important problem and one to which a good deal of attention has been paid in recent years. It would be no great exaggeration to say that insects have been responsible for more loss of life and destruction of property than that caused by wars, floods, earthquakes, fires and famines in the history of man. Advance in civilization is producing conditions suitable for insect multiplication in many places, in spite of all efforts to the contrary. On a moderate computation the annual loss caused to India through insect pests has been put at 2,000 millions of rupees and over a million and a half of human lives. An effective defence against these enemies of social and economic progress will materially reduce this enormous wastage and facilitate national development. One of the necessities for combating this menace is to find cheap and effective insecticides, commensurate with the means of the great masses in India whose economic condition is very low. At the present time our knowledge of plants bearing insecticidal properties in this country is very meagre indeed. A thorough enquiry into this aspect of poisonous plants is, therefore, of prime importance to the country. For several reasons vegetable insecticides are preferable to the mineral ones, such as arsenicals, copper compounds, mineral oils, etc. Those from vegetable sources are undoubtedly less deleterious to human beings and other warm-blooded animals generally and they are also less harmful from the point of view of agriculture. Most of the mineral insecticides at the present time are imported from foreign countries and are therefore expensive. So far as the insecticides from the plant kingdom are concerned, so little is known in this country that we have to depend on those growing in other countries. The larger the number of effective insecticides we discover from among our poisonous plants the greater will be the chances of their being brought into extensive use by the people for medical, veterinary, agricultural and household purposes.

Of the vegetable insecticides of proved value may be mentioned *Chrysanthemum* (*pyrethrum*), *Derris* (tuba-root), *Nicotiana* (tobacco), *Tephrosia*, *Picrasma* (quassia), *Delphinium* (larkspur), *Veratrum*, etc. Attemps are now being made to cultivate *pyrethrum* in India on account of its effectiveness in destroying insects and mosquito larvae. *Derris elliptica* Benth. is found to a very limited extent in India, but several allied species found here are worth investigating. Of these *Derris ferruginea* Benth. has been recently shown to contain rotenone and may prove to be a good insecticide. Tobacco is largely cultivated in India. *Tephrosia vogelli* Hook. *f*. has been shown in foreign countries to be an efficient insecticide for fleas, lice and ticks and it has been suggested that it may be used as a cheap commercial dip for cattle. Some of the other species of *Tephrosia* are also stated to have insecticidal properties, but several of the Indian species although met with in abundance remain uninvestigated. Indian species of *Picrasma* also need investigation and we have been informed that powdered young leaves and twigs of *P. napaulensis* Benn. are used to kill mosquito larvae in Assam. Several Indian species of *Delphinium* are already used for destroying maggots in wounds and may be potential insecticides. Furthermore it has been stated that the alkaloid cytisine is an important constituent of the Persian and Australian

insect powder. This alkaloid, which resembles nicotine in its action, has been found in at least six genera of which *Euchresta* and *Sophora* are represented in India.

Hackett, Russell and others (Bulletin of the Health Organisation, League of Nations, 1938) discuss the naturalistic methods in practice for the control of mosquito larvae and refer to the role of the plant kingdom for this purpose. It is stated that pollution by vegetable matter in the form of industrial wastes has often been tried with success as an anti-malarial measure. In a case reported from the Philippines bagasse from sugarcane mills seemed to be keeping a stream free from *flavirostris* ; the refuse from the Government Sisal Experiment Station is alleged to have a similar action, while the numerous large pits used for macerating *canepa* hemp in Italy do not breed anophelines. Stagnant pools, such as engineering borrow-pits into which green cut vegetation has been thrown, are stated to breed culicines only, anophelines being inhibited. The lethal effect of a fortnight-old brew of cut grass is said to be remarkable. The extention of this method in the form of ' herbage-packing ' to shallow, small-volume, running channels has been advocated by Williamson and the present authors. They think that the effect of this is not mechanical but biological, and consider that the use of green cut vegetation is very important, for dry straw will only result in a hay infusion favourable to larval growth. It is not every plant, however, that is suitable in the case of running water. According to these authors, ' The best so far found in India are *Cleistanthus* species and *Holorrhena antidysenterica* (sic). The first of these are fish poisons ; the latter contains several alkaloids.'

We are confident, however, that many more plants, mentioned in the synopsis at the end of this article would be found equally good or even better for this purpose, but the piscicidal plants in connexion with this must be employed with caution, since it is inadvisable to use them if the water contains fishes, or drains into tanks or reservoirs containing them.

There are also a number of plants which are utilized as insect repellents, e.g. roots of costus, *Saussurea lappa* C. B. Clarke, essential oil from *Eucalyptus globulus* Labill., leaves of *neem*, *Azadirachta indica* Juss., and of patchouli, *Pogostemon heyneanus* Benth., etc. The investigation of vegetable insecticides and insect repellents from among the vast potential resources existing in this country will repay scrutiny.

(*b*) *Plants poisonous to fish*.—That there are many plants in the Indian flora which have deleterious effect on fish is well known. Wholesale poisoning of fish in ponds, streams and pools by means of these plants is very uneconomical and is not allowed in any civilized country, but cases are known where such plants have come into contact with water and enormous numbers of fish have died as a result. This aspect of these plants, though not perhaps so important as the other, cannot be entirely left out of consideration in the study of poisonous plants. The list of plants growing in India having a poisonous action on fish is very long and a large number of them have been referred to in the book, *Indigenous Drugs of India* ; lately considerable additions have been made which may be of interest to those wanting further information. This group is of importance, as some of the insecticides are

also piscicides and *vice versa* and a systematic investigation of this group may lead to the discovery of effective insecticides, which is the crying need of this country at the present time.

We have briefly referred to the toxicological aspects of plants growing in India in a very general way. A good deal of work has been done in connexion with poisonous plants in Europe, America, South Africa and other countries, yet little or no systematic work has so far been attempted in India. The senior author was deeply impressed with this regrettable state of affairs when he took up work on Indian indigenous drugs nearly twenty years ago. Unfortunately it was not possible to start even a general survey of this group till a few years ago when the Imperial Council of Agricultural Research gave a grant and added a botanical section to the already-existing unit composed of chemists and pharmacologists paid by funds generously given by the Indian Research Fund Association twelve years ago. With this team of enthusiastic workers a beginning was made. To start with, three thousand circulars were sent out to the forest, veterinary, medical and agriculture departments of different provinces, to universities and to individual workers all over India. Different parts of the country were visited and first-hand information from all local sources by extensive investigations carried out in the field was obtained. All the existing herbaria were scrutinized, the information thus collected was analysed and a monograph on the subject of Poisonous Plants of India is now in the course of preparation. A list of nearly 700 plants reputed to be poisonous to man, livestock, insects, fish, etc., has been prepared which is by far the largest so far collected in this country. In the case of many plants, poisonous properties are suspected but have not been substantiated by chemical analysis and pharmacological experimentation. This is now being done so far as is possible with the resources at our disposal and preliminary chemical examinations of many important plants are being made. A thorough and comprehensive study of all these plants is the work of many years, perhaps of several generations. In the present work we are getting together all available information, botanical, chemical and pharmacological, in connexion with poisonous plants growing in India together with all references in the literature. The monograph, when completed, will serve as a basis for future work on these plants, the importance of which from an economic point of view cannot be overrated.

A conspectus of poisonous Phanerogams (including food poisons) growing in India, either in a state of nature or under cultivation, is appended. This will give some idea as to the ground covered in our recent investigations and the scope of the monograph, which will be profusely illustrated. The plants have been dealt with according to Bentham and Hooker's system of classification and the important active principles occurring in each family have been given and the main effects produced have been briefly discussed. Special attention has been paid to the nomenclature of plants and adherence to the International Rules has caused, unfortunately, several departures from the names used in *The Flora of British India*. A large number of plants, as described in that monumental work, are differently understood or are differently named or spelt by modern botanists. Some of these changes have now become well known in India. In this brief article, we have not attempted

to point out all departures from *The Flora of British India*, but have only indicated some of the less-established changes in this direction which were considered necessary.

We take the opportunity of expressing our gratitude to the Imperial Council of Agricultural Research for the generous grant to this inquiry and to all our colleagues of the indigenous drugs inquiry and of the Calcutta School of Tropical Medicine, the forest, agricultural, veterinary and medical departments of various provinces and Indian states, the Superintendent, Royal Botanic Gardens, Sibpur, the Botanical Survey of India, the chemical examiners, universities, and other individuals who have helped us in this important work, both in the field and in the laboratories and herbaria.

Poisonous Plants of India

Families and active principles	Names of plants	General remarks
1. *Ranunculaceae* (Buttercup Family) Anemonin, aconitin, indaconitin, pseudaconitin, adonidin, delphinine, staphysagroine, cyanogenetic glucosides, essential oils, saponins, etc.	1. *Aconitum balfourii* Stapf, *A. chasmanthum* Stapf *ex* Holmes, *A. deinorrhizum* Stapf, *A. elwesii* Stapf, *A. falconeri* Stapf, *A. ferox* Wall, *ex* Seringe, *A. laciniatum* Stapf, *A. laeve* Royle, *A. lethale* Griff., *A. luridum* Hk. *f.* & T., *A. moschatum* Stapf, *A. soongaricum* Stapf, *A. spicatum* Stapf, *A. violaceum* Jacq.	Cardiac depressant and nerve poison; cause deaths among livestock; also used as arrow poison
	2. *Actaea spicata* Linn.	Acrid and poisonous; deaths among horses reported
	3. *Adonis aestivalis* Linn., *A. chrysocyathus* H. *f.* & T.	Poisonous to animals; heart poison
	4. *Anemone obtusiloba* D. Don.	Vesicant; taken internally produces vomiting and purging, drying alters properties
	5. *Aquilegia vulgaris* Linn.	Poisonous
	6. *Caltha palustris* Linn.	Acrid and poisonous; deaths among horses reported
	7. *Cimicifuga foetida* Linn.	Heart depressant; insect repellent
	8. *Clematis gouriana* Roxb., *C. graveolens* Lindl., *C. napaulensis* DC., *C. orientalis* Linn., *C. triloba* Heyne, *C. wightiana* Wall.	Blistering, properties altered by drying

	9. *Delphinium brunonianum* Royle, *D. caeruleum* Jacq., *D. elatum* Linn., *D. vestitum* Wall.	Cardiac and respiratory depressants; acrid taste, insecticidal, poisonous to animals
	10. *Nigella sativa* Linn.	Abortive in larger doses
	11. *Paeonia emodi* Wall.	Narcotic
	12. *Ranunculus arvensis* Linn., *R. falcatus* Linn., *R. laetus* Wall., *R. lingua* Linn., *R. pensylvanicus* Linn. *f.*, *R. sceleratus* Linn.	Vesicant and poisonous to livestock when fresh; drying alters properties
2. *Magnoliaceae* (Magnolia and Champa Family) Shikimin, illicin, essential oils	1. *Illicium griffithii* Hk. *f.* & T., *I. religiosum* Sieb. & Zucc.	Star anise of China (*I. verum* Hook. *f.*) imported into India sometimes adulterated with *I. religiosum*; has produced deaths. The latter is respiratory and cardiac poison. Indian *I. griffithii* also referred to as poisonous
3. *Annenaceae* (Custard apple Family) Resin, alkaloid, etc.	1. *Annona reticulata* Linn., *A. squamosa* Linn.	Seeds intensely irritant to conjunctiva; locally used as abortifacient, insecticidal; roots drastic purgative
4. *Menispermaceae* (Moonseed Family)	1. *Anamirta cocculus* (Linn.) W. & A.	Convulsant poison; insecticide; used to poison fish and cattle
Picrotoxin, saponins	2. *Pachygone ovata* (Poir.) Miers	Insecticide, piscicide
5. *Berberidaceae* (Barberry Family)	1. *Berberis aristata* DC. (and probably few more species)	Poisonous to lower animals; piscicide
Berberine, podophyllum resin	2. *Podophyllum hexandrum* Royle (= *P. emodi* Wall. *ex* Hk. *f.* et T.).	Drastic purgative, resin irritant to mucous membranes

Families and active principles	Names of plants	General remarks
6. *Papaveraceae* (Poppy Family)	1. *Argemone mexicana* Linn.	Oil occasionally mixed with mustard oil ; adulterated mustard oil experimentally produced condition resembling epidemic dropsy
Morphine, codeine, protopine, thebaine, papaverine, narcotine, narceine, etc.	2. *Meconopsis aculeata* Royle, *M. napaulensis* DC.	Roots narcotic
	3. *Papaver dubium* Linn., *P. nudicaule* Linn., *P. rhoeas* Linn., *P. somniferum* Linn.	All species yield opium more or less, *P. somniferum* the chief source ; opium used for suicidal purposes
7. *Cruciferae* (Mustard Family) Glucosides on contact with water produce vesicant essential oils	1. *Brassica cernua* (Thunb.) Forbes et Hemsl., *B. integrifolia* (West) O. E. Schulz, *B. juncea* (Linn.) Czernjaew et Cosson (*rai*) ; *B. napus* Linn. with four varieties (*toria, sarson*) ; *B. nigra* (Linn.) Koch (black mustard)	Vesicant ; mustard cakes if fed in large amounts and over prolonged periods harmful to cattle, *sarson* cake safest, mixture with *rai* or black or white mustard dangerous
	2. *Lepidium draba* Linn.	Fish poison
	3. *Sinapis alba* Linn. (white mustard)	Discussed under *Brassica*
8. *Capparidaceae* (Caper Family)	1. *Capparis aphylla* Roth	Vesicant
Essential oils	2. *Cleome felina* Linn. f., *C. viscosa* Linn.	Vesicant
	3. *Gynandropsis gynandra* (Linn.) Merr. (*G. pentaphylla* DC.).	Insecticide, piscicide, vesicant

9. *Bixaceae* (Chaulmoogra Family)	1. *Gynocardia odorata* R. Br.	Fruit piscicide
Cyanogenetic glucoside; chaulmoogra oil	2. *Hydnocarpus kurzii* (King) Warb. (=*Taraktogenos kurzii* King), *H. laurifolia* (Dennst.) Sleumer (=*H. wightiana* Bl.)	Fruit piscicide. Seed oil gastro-intestinal irritant
10. *Polygalaceae* (Milkwort Family)	1. *Polygala chinensis* Linn., *P. crotalarioides* Buch.—Ham., *P. telephioides* Willd.	Expectorant, emetic, acrid
Saponins		
11. *Caryophyllaceae* (Carnation Family)	1. *Saponaria vaccaria* Linn., and probably some others of the family	Acrid; toxicity partially removed by boiling
Saponins		
12. *Hypericaceae* St. John's-wort Family Balsamic resinous juice	1. *Hypericum perforatum* Linn.	Poisonous to animals, especially horses if taken in excess, usually however not eaten
13. *Guttiferae* (Gamboge Family)	1. *Calophyllum inophyllum* Linn.	Fish poison
Gum resins	2. *Garcinia morella* Desrouss and probably others	Gum resin violent gastro-intestinal irritant
14. *Ternstroemiaceae* (Tea Family)	1. *Thea sinensis* Linn.	Excessive indulgence harmful
Caffeine, theophylline		
15. *Malvaceae* (Cotton Family)	1. *Gossypium* species	Root bark emmenagogue and used as abortifacient, occasional harmful effects of cotton seed cake on animals reported
Gossypol, resin, ephedrine, pseudo-ephedrine		

Families and active principles	Names of plants	General remarks
15. *Malvaceae*—contd.	2. *Malva parviflora* Linn.	Narcotic effects on animals reported
	3. *Sida rhombifolia* Linn.	Ripe capsules reported fatal to fowls
16. *Linaceae* (Flax Family)	1. *Erythroxylum coca* Lam.	Central nervous stimulant; sensory nerve endings—paralysant; addiction harmful
Cyanogenetic compounds; cocaine	2. *Linum usitatissimum* Linn.	Young plants produced deaths in animals; sometimes seed cake also harmful
17. *Zygophyllaceae* (Bean-caper and Guaicum Family)	1. *Peganum harmala* Linn.	Insecticide, narcotic, nauseant and emetic. Used as abortifacient, protoplasmic poison; paralyses skeletal and cardiac muscles of frogs
Harmine, harmaline, harmalol, peganine, essential oils, saponins, resins	2. *Tribulus terrestris* Linn.	Causes geeldikkop (dikgeel) in South Africa in small stock; characterized by oedema of head, fever and jaundice
18. *Rutaceae* (Rue Family)	1. *Acronychia pedunculata* (Linn.) Miq. (=*A. laurifolia* Bl.)	Fish poison
Essential oils, rutin, skimmianine, saponins, resins, etc.	2. *Ruta graveolens* Linn. var. *angustifolia* Hk. *f.*, *R. tuberculata* Forsk.	Acro-narcotic poison, rubefacient; oil and herb frequently used to produce criminal abortion
	3. *Skimmia laureola* Sieb. & Zucc. *ex*-Walp.	Reported poisonous to sheep and goats

	4. *Zanthoxylum alatum* Roxb. (probably some more species)	Fish poison
19. *Simarubaceae* (Bitter-bark Family) Essential oils, saponins, resins, bitter substances	1. *Ailanthus altissima* (Mill.) Swingle (= *A. glandulosa* Desf.)	Nauseant, nervous system depressant, accumulation of its leaves in well water reported to produce chronic gastritis
	2. *Balanites roxburghii* Planch.	Fish poison, purgative
	3. *Brucea sumatrana* Roxb.	Seeds produce nausea, vomiting, abdominal pain and purging
	4. *Picrasma napalensis* Benn.	Stated to be used as larvicide in Sikkim
20. *Meliaceae* (Neem & mahogany Family) Bitter substances, bitter oil, saponins	1. *Azadirachta indica* A. Juss	Parasiticidal, leaves used as insect repellent
	2. *Melia azedarach* Linn.	Berries especially poisonous to man and animals; narcotic and gastro-intestinal irritant
	3. *Walsura piscidia* Roxb.	Dangerous emmenagogue, violent emetic, largely used as a fish poison
21. *Celastraceae* (Spindle-tree Family) Alkaloid, essential oil, resin	1. *Elaeodendron glaucum* Pers.	Emetic ; overdoses fatal
22. *Sapindaceae* (Soap-nut Family) Saponins, cyanogenetic compounds	1. *Cardiospermum halicacabum* Linn.	Leaves emetic and rubefacient
	2. *Dodonaea viscosa* Linn.	Fish poison ; deleterious to camels

Families and active principles	Names of plants	General remarks
22. *Sapindaceae*—contd.	3. *Harpullia cupanioides* Roxb.	Fish poison
	4. *Melianthus major* Linn.	Produces acute diarrhoea, salivation and colic ; honey from flowers stated to be poisonous
	5. *Sapindus mukorossi* Gaertn., *S. trifoliatus* Linn.	Fish poison, emetic, purgative ; used for procuring abortion
	6. *Schleichera oleosa* (Lour.) Merr. (=*S. trijuga* Willd.).	Oil occasionally mixed with mustard oil or ghee produces irritant poisoning ; seeds used as insecticide
23. *Anacardiaceae* (Cashew & mango Family) Toxic phenolic compounds, toxic resin	1. *Anacardium occidentale* Linn.	Pericarp contains powerfully vesicant juice, used to preserve floors, wood, books, etc. from white ants ; tar from bark also vesicant
	2. *Holigarna arnottiana* Hook. *f.*, *H. ferruginea* March, *H. grahamii* (wight) Hook. *f.*, *H. longifolia* Buch.-Ham. *ex* Roxb.	Juice vesicant although not equally powerful in all species
	3. *Rhus insignis* Hook. *f.*, *R. punjabensis* J. L. Stewart, *R. succedanea* Linn., *R. wallichii* Hook. *f.*	Dreaded by local people ; even smoke from burning wood dreaded ; juice vesicant
	4. *Semecarpus anacardium* Linn. *f.*, *S. travancoricus* Bedd.	Pericarp contains vesicant juice. Sometimes used locally as abortifacient
24. *Coriariaceae* (Coriaria Family) Coriamyrtin, tutin in foreign species	1. *Coriaria nepalensis* Wall.	Stated to be narcotic ; foreign species very poisonous acting like picrotoxin and producing convulsions

25. *Moringaceae* (Horse-radish Family) Essential oils, alkaloid, moringine, moringinine	1. *Moringa oleifera* Lamk. (=*M. pterygosperma* Gaertn)	Fresh root bark vesicant, used to procure abortion. Moringinine acts on the sympathetic nervous system
26. *Leguminosae* (Pea Family) Alkaloids ; glucosides, saponins, cyanogenetic compounds, rotenone, toxic albumin, bitter substances, globulins	1. *Abrus precatorius* Linn.	Specially blood poison, used to poison cattle and to procure abortion
	2. *Acacia pennata* Willd.	Fish poison
	3. *Albizzia procera* Benth.	Fish poison
	4. *Butea monosperma* (Lam.) O. Ktze. (=*B. frondosa* Koen. *ex*-Roxb.)	Seeds insecticide ; painful if taken internally
	5. *Caesalpinia nuga* Ait	Fish poison
	6. *Canavalia virosa* W. & A. (*C. ensiformis* DC. var. *Virosa* Baker)	Fruit stated to be poisonous
	7. *Cassia absus* Linn., *C. acutifolia* Delile, *C. alata* Linn., *C. angustifolia* Vahl, *C. fistula* Linn., *C. obovata* Collad	Purgative ; irritant in large doses, *C. absus* seeds dangerous application to eyes. *C. alata* fish poison
	8. *Clitoria ternatea* Linn.	Roots powerful cathartic like Jalap ; not a safe medicine
	9. *Cytisus scoparius* Link.	Plants not eaten by cattle ; emetic and cathartic
	10. *Dalbergia stipulacea* Roxb.	Fish poison
	11. *Derris elliptica* Benth., *D. scandens* Benth., *D. uliginosa* Benth., (Possibly *D. ferruginea* Benth.)	Fish poison. *D. elliptica* is insecticidal

Families and active principles	Names of plants	General remarks
26. *Leguminosae*—contd.	12. *Entada phaseoloides* (Linn.) Merr. (=*E. scandens* Benth.)	Fish poison
	13. *Lathyrus aphaca* Linn., *L. sativus* Linn.	Food and fodder. *L. sativus* if taken in larger amounts and over prolonged period produces lathyrism in men and animals. Ripe seeds of *L. aphaca* stated to be narcotic in excess
	14. *Melilotus alba* Desr.	Stated to be poisonous to cattle
	15. *Milletia auriculata* Baker, *M. pachycarpa* Benth., *M. piscidia* Wight	Fish poison; *M. auriculata* is an insecticide
	16. *Mundulea suberosa* Benth	Fish poison
	17. *Ougenia dalbergioides* Benth	Fish poison
	18. *Phaseolus lunatus* Linn.	Coloured variety sometimes exhibits poisonous properties if eaten
	19. *Pithecellobium bigeminum* Mart.	Fish poison. Seeds stated to be eaten in Burma but sometimes produce disastrous results
	20. *Pongamia pinnata* (Linn.) Merr. (=*P. glabra* Vent.)	Piscicide and insecticide
	21. *Sophora mollis* R. Grah., and Var. *hydaspidis* Baker, *S. tomentosa* Linn.	Seeds of *S. mollis* insecticidal; leaves of *S. tomentosa* powerfully emetic and cathartic in large doses

	22. *Tephrosia candida* Linn., *T. purpurea* Pers. (F. B. I. in part)	Fish poison. Some foreign species are insecticides. Species of *Tephrosia* in India likely to prove of value as insecticides
	23. *Trifolium repens* Linn.	Highly prized fodder in Europe. Very suspicious in Himalayas where poisoning reported in horses
	24. *Vicia sativa* Linn.	Suspected to cause lathyrism—see *Lathyrus sativa*
27. *Rosaceae* (Rose Family) Cyanogenetic glucosides, phloridzin	1. *Prunus amygdalus* Batsch. (bitter variety), *P. armeniaca* Linn., (bitter variety), *P. avium* Linn., *P. cerasus* Linn., *P. mahaleb* Linn., *P. padus* Linn., *P. persica* Stokes., *P. puddum* Roxb., *P. undulata* Buch.—Ham.	Seeds poisonous, leaves of many said to be dangerous to livestock when wilted ; harmless when on the plant, suspicious when dried
	2. *Pygeum gardneri* Hook. *f.*	Seeds fish poison
	3. *Pyrus aucuparia* Linn., *P. malus* Linn.	Bark of *P. aucuparia* irritant to the alimentary tract ; wilting leaves of other occasionally poisonous to animals browsing upon them
	4. *Rubus moluccanous* Gaertn.	Leaves reported as powerful emmenagogue and abortifacient
28. *Crassulaceae* (Life-plant Family) Glucosides—in foreign species	1. *Kalanchoe spathulata* DC.	Expressed juice of bitter variety drastic purgative ; poisonous to goats, not eaten by cattle ; leaves said to be insecticide
29. *Droseraceae* (Sundew Family)	1. *Drosera peltata* Sm. var. *lunata* Clarke, *D. spathulata* Labill. (*D. burmanni* Vahl)	Rubefacient. Some Australian species reported injurious to sheep

Families and active principles	Names of plants	General remarks
30. *Combretaceae* (Myrobolan Family) Tannins	1. *Terminalia bellerica* Roxb., *T. chebula* Retz.	*T. bellerica* reported fish poison ; kernel stated to be poisonous and cases reported where narcotism followed nausea and vomiting, evidence however conflicting. Some varieties of *T. chebula* drastic purgative
31. *Myrtaceae* (Myrtle and *jamun* Family) Saponins, essential oils, tannins	1. *Barringtonia acutangula* Gaertn., *B. asiatica* Kurz. (=*B. speciosa* Forst.), *B. racemosa* Bl.	Fish poisons
	2. *Careya arborea* Roxb.	Fish poison, inner bark rubbed on shoes keeps off leeches
	3. *Eucalyptus globulus* Labill.	Essential oil an important ingredient of insecticides ; internally gastro-intestinal irritant
	4. *Melaleuca leucadendron* Linn.	Essential oil is an irritant and a mosquito repellent
32. *Lythraceae* (Henna and pomegranate Family) Acrid principle	1. *Ammania baccifera* Linn., *A. senegalensis* Lamk.	Acrid, vesicant ; internally cause great pain
	2. *Lagerstroemia indica* Linn., *L. speciosa* (Linn.) Pers. (=*L. flos-regineae* Retz.)	Bark and leaves purgative ; seeds of former narcotic
33. *Samydaceae* (Casearia Family)	1. *Casearia graveolens* Dalz., *C. tomentosa* Roxb.	Pounded fruit used as a fish poison

34. *Caricaceae* (Papaw Family) Carpaine, carposide, caricin in seeds yielding essential oil on hydrolysis ; papain	1. *Carica papaya* Linn	Seeds believed to be powerfully emmenagogue and used as abortifacient. The juice of unripe fruit acrid or even vesicant
35. *Passifloraceae* (Passion-flower Family) Hydrocyanic acid, saponins	1. *Adenia* (*Modecca*) *palmata* Engl., *A. wightiana* Engl.	Roots and fruits poisonous. Deaths from fruits of *A. palmata* reported
36. *Cucurbitaceae* (Cucumber Family) Bitter substances, such as colocynthin, alkaloids, glucosides, saponins	1. *Citrullus colocynthis* Schrad, *C. vulgaris* Schrad (bitter variety)	Fruit purgative ; *C. colocynthis* a drastic purgative has produced fatal results, dust when dry very irritating to eyes and nostrils
	2. *Corallocarpus epigaeus* Benth. & Hook. *f.*	Fruit drastic purgative
	3. *Cucumis sativus* Linn. (bitter variety), *C. trigonus* Roxb.	Fruit purgative, *C. trigonus* excessively so
	4. *Lagenaria vulgaris* Seringe (Wild variety)	Drastic purgative, case reported where beer kept in bottle gourd produced poisoning
	5. *Luffa acutangula* Roxb. var. *amara* C. B. Clarke, *L. aegyptiaca* Mill. *ex*-Hook. *f.* (wild variety), *L. echinata* Roxb.	Fruit of *L. acutangula* var. *amara* violently emetic and purgative, is not eaten ; others also purgative
	6. *Momordica balsamina* Linn., *M. charantia* Linn., *M. tuberosa* Cogn. (=*M. cymbalaria* Fenzl)	Fruit of *M. balsamina* fatal to dogs. Death from violent vomiting and purging from juice of plant. *M. charantia*, roots used as abortifacient. Decoction of roots of *M. tuberosa* used as abortifacient

Families and active principles	Names of plants	General remarks
36. *Cucurbitaceae*—contd.	7. *Trichosanthes bracteata* Voigt (=*T. palmata* Roxb.), *T. cucumerina* Linn., *T. dioica* Roxb. ..	Root powerful cathartic. Fruit of *T. cucumeriana* never eaten, because of powerful cathartic action. Fruit of *T. bracteata* used as cattle poison and to destroy crows
	8. *Zanonia indica* Linn.	Fruit very acrid and cathartic
37. *Begoniaceae* (Begonia Family)	1. *Begonia rex* Putzeys	Juice poisonous to leeches
38. *Ficoideae*	1. *Trianthema portulacastrum* Linn. (*T. monogyna* Linn.), *T. pentandra* Linn.	Roots irritant and cathartic. Leaves and stems used as pot herb but occasionally said to produce paralysis and diarrhoea
39. *Umbelliferae* (Carrot and coriander Family)	1. *Apium graveolens* Linn.	Seeds irritant, poison in overdoses
Essentia oils, cicutoxin, cicutoxinin, vellerin	2. *Centella asiatica* (Linn.) Urb. (= *Hydrocotyle asciatica* Linn.).	Stupefying narcotic in larger doses; a cumulative poison
	3. *Cicuta virosa* Linn.	Cause of extensive poisoning in Europe, the active principle belongs to picrotoxin in group of poisons which are convulsant
	4. *Daucus carota* Linn.	Seeds used for procuring abortion, tuberous roots eaten
	5. *Hydrocotyle javanica* Thunb.	Stated to be a fish poison

40. ***Araliaceae*** **(Ivy and Panax Family)**	1. *Hedera helix* Linn.	Decoction of leaves used to kill lice; other poisonous properties also assigned
Resin, α—hederin saponin		
41. ***Caprifoliaceae*** **(Honey-suckle Family)**	1. *Sambucus ebulus* Linn., *S. nigra* Linn.	Strongly purgative. *S. ebulus* has foetid smell when bruised, is not eaten by cattle; poisoning amongst boys and fowls reported
Sambucine, cyanogenetic glucoside, sambunigrin, bitter substances, resin (cathartic)		
42. ***Rubiaceae*** **(Madder and coffee Family)**	1. *Adina cordifolia* Benth. & Hook. *f.*	Juice used as insecticide
Quinine, quinidine, cinchonine, cinchonidine, caffeine, emetine, cephaeline, ipecacuanhin, essential oils, saponins	2. *Cinchona calisaya* Wedd. and var. *ledgeriana* Howard, *C. officinalis* Linn. *f.*, *C. succirubra* Pavon.	Source of cinchona alkaloids, general protoplasmic poison and parasiticide; plants fish poisons
	3. *Coffea arabica* Linn.	Excessive indulgence harmful, chronic poisoning
	4. *Psychotria ipecacuanha* Stokes	Emetic and irritant and cardiac depressant
43. ***Compositae*** **(Sun-flower Family)**	5. *Randia dumetorun* Lamk., *R. uliginosa* DC.	Fish poisons; *R. dumetorum* used to preserve grain from attacks of insects, used as abortifacient
Essential oils, artemisin, santonin, bitter substances (absinthin, lactucin, etc.), saponins, resin, senecio, alkaloids, xanthostrumarin, pyrethrins	1. *Anthemis cotula* Linn.	Undesirable food for livestock; acrid and vesicant
	2. *Artemisia absinthium* Linn., *A. maritima* Linn., *A. vulgaris* Linn.	Essential oil from *A. absinthium* violent narcotic poison producing convulsions; *A. maritima* irritant poison in large doses, fatal cases reported; *A. vulgaris* produces epileptiform spasms, also reported fish poison

Families and active principles	Names of plants	General remarks
43. *Compositae*—contd.	3. *Centhratherum anthelminticum* O. Ktze (=*Vernonia anthelmintica* Willd.)	Used as insecticide and insect repellent
	4. *Chrysanthemum cinerariifolium* Vis. *C. coccineum* Willd. (*C. roseum* Adam.)	Reputed insecticides
	5. *Erigeron canadensis* Linn.	Irritant
	6. *Eupatorium odoratum* Linn.	Stated fish poison ; *U. urticifolium* L. *f.* of foreign countries produces acidosis and trembles in sheep and cattle
	7. *Gnaphalium luteo-album* Linn.	Suspected of causing livestock-poisoning in South Africa
	8. *Inula graveolens* Desf.	Suspected poisonous to livestock
	9. *Lactuca tatarica* C. A. Meyer, var. *tibetica* C. B. Clarke	Occasionally browsed by sheep ; sometimes injurious
	10. *Saussurea lappa* C. B. Clarke	Roots used against insects
	11. *Senecio* species (*S. vulgaris* Linn. introduced plant)	Important genus, worth study in India ; ragwort poisoning due to several species well known in foreign countries ; various species produce hepatic cirrhosis
	12. *Sphaeranthus indicus* Linn.	Fish poison
	13. *Xanthium strumarium* Linn.	Reported poisonous to cattle and pigs in America and Australia

44. *Campanulaceae* (Bell-flower Family) Alkaloids	1. *Lobelia excelsa* Leschen., *L. nicotianifolia* Heyne	Irritants to nose, death reported in man, action like nicotine, except more burning pain in the stomach, used as substitute for *datura*
45. *Ericaceae* (Rhododendron Family) Andromedotoxin, ericolin, essential oils	1. *Gaultheria fragrantissima* Wall.	Irritant poison ; deaths reported from use as abortifacient
	2. *Pieris ovalifolia* D. Don.	Poisonous to goats ; insecticide
	3. *Rhododendron anthopogon* D. Don., *R. arboreum* Sm., *R. barbatum* Wall., *R. campanulatum* D. Don., *R. cinnabarinum* Hook. *f.*, *R. falconeri* Hook. *f.*, *R. setosum* D. Don.	Probably all poisonous to stock ; some reported fish poisons ; honey from some reported poisonous
46. *Plumbaginaceae*— (Plumbago Family) Plumbagin	1. *Plumbago indica* Linn. (=*P. zeylanica* Linn.,) *P. rosea* Linn.	Strong irritant externally and internally ; used to procure abortion
47. *Primulaceae*— (Prim-rose Family) Saponins	1. *Anagallis arvensis* Linn.	Produces gastro-enteritis in dogs and horses ; used to poison fish and expel leeches from nostrils of animals
	2. *Cyclamen persicum* Miller	Fish poison
	3. *Primula reticulata* Wall.	Stated to be poisonous to cattle
48. *Myrsinaceae*— (Ardisia Family) Saponins	1. *Maesa indica* Wall.	Leaves stated as fish poison
49. *Sapotaceae*— (Sapodilla and mohwa Family) Saponins	1. *Madhuca (Bassia) latifolia* (Roxb.) Macbride, *M. longifolia* (Linn.) Macbride	Residual cake used as fish poison ; said to be insecticide and used to kill worms on lawns (*mohwa* meal)
50. *Ebenaceae*— (Ebony Family)	1. *Diospyros ebenum* Koenig, *D. montana* Roxb., *D. paniculata* Dalz	Fish poisons

Families and active principles	Names of plants	General remarks
51. *Salvadoraceae*—(Salvadora Family)	1. *Salvadora oleoides* Dcne., *S. persica* Linn.	Root bark vesicant
52. *Apocynaceae*—(Dog-bane and Oleander Family) 'dita' 'kurchi' and rauwolfia alkaloids; glucosides, e.g. cerberin, karabin, neriin, neriodorein, neriodorin, oleandrin, 1-strophanthin, thevetin etc.; bitter substances	1. *Allamanda cathartica* Linn.	Hydragogue cathartic
	2. *Cerbera manghas* Linn. (=*C. odollam* Gaertn.)	Green fruit used to poison dogs; seeds irritant poison; plant fish poison
	3. *Ervatamia dichotoma* (Roxb.) Blatter (= *Tabernaemontana dichotoma* Roxb.)	Seeds powerfully narcotic and poisonous
	4. *Holarrhena antidysentrica* Wall.	Not browsed by cattle and goats; anthelmintic; kurchicine general protoplasmic poison.
	5. *Lochnera pusilla* K. Schum (=*Vinca pusilla* Murr., *L. rosea* (Linn.), Reichb. (=*Vinca rosea* Linn.)	Cardiac poisons; *L. pusilla* regarded as poisonous to cattle
	6. *Melodinus monogynous* Roxb.	Fish poison
	7. *Nerium indicum* Mill (=*N. odorum* Soland)	Very poisonous. Used for suicidal purposes and to procure abortion; depresses nervous system and heart
	8. *Plumeria acuminata* Ait. (=*P. acutifolia* Poir.)	Milk rubefacient, used to procure abortion; internally purgative. Poisonous
	9. *Rauwolfia serpentina* Benth. ex Kurz	Hypnotic, fish poison
	10. *Thevetia peruviana* (Pers.) Merr. (=*T. neriifolia* Juss.)	All parts especially seeds very poisonous. Used to poison cattle; produces violent vomitting and purging. Action on heart like digitalis. Fish poison

53. *Asclepiadaceae*— (Milk-weed Family)	1. *Asclepias curassavica* Linn.	Fish poison, emetic, cathartic
	2. *Calotropis gigantea* R. Br., *C. procera* R. Br.	Milk drastic purgative, caustic ; stated to be used for suicidal and homicidal purposes and as an abortifacient and cattle poison
	3. *Cryptostegia grandiflora* R. Br.	Fatal case due to leaves reported in which persistent vomiting observed.
	4. *Cynanchum arnottianum* Wight, *C. vincetoxicum* Pers.	*C. arnottianum* used as insecticide, *C. vincetoxicum* not eaten by cattle and regarded poisonous ; root emetic.
	5. *Sarcostemona acidum* (Roxb.) Voigt (=*S. brevistigma* W. & A.)	Stated to have insecticidal properties.
	6. *Secamone emetica* R. Br.	Root acrid ; plant powerfully emetic.
	7. *Tylophora indica* (Burm. *f.*) Merr. (=*T. asthmatica* Wight and Arn.), *T. fasiculata* Buch.—Ham.	Fatal cases reported in man ; emetic ; *T. fasciculata* used as rat poison
54. *Loganiaceae*— (Nux-vomica Family) strychnine, brucine, etc.	1. *Strychnos colubrina* Linn., *S. nux-vomica* Linn.	Poisonous. *S. nux-vomica* seeds used as fish poison and source of strychnine, one of the deadliest poisons known, suicidal and homicidal cases recorded, employed to kill dogs ; rodents, etc.
55. *Boraginaceae*— (Borage and Sebestan Family) Alkaloids	1. *Heliotropium eichwaldii* Steud., *H. indicum* Linn.	Suspected to be poisonous
56. *Convolvulaceae*— (Convolvulus Family) Convolvulin, pharbitin, terpithin, terpethein, cucutalin, resin	1. *Calonyction muricatum* (Linn.) G. Don. (=*Ipomoea muricata* Jacq.)	See *Ipomoea*
	2. *Convolvulus arvensis* Linn., *C. scammonia* Linn.	Roots strongly purgative
	3. *Cuscuta reflexa* Roxb.	Nauseant and emetic ; used to procure abortion
	4. *Ipomoea reptans* (Linn.) Poir. (=*I. aquatica* Forsk.), *I. nil* Roth (=*I. hederacea* Jacq.), *I. purga* Heyne.	Strongly purgative ; irritant poisons in overdoses
	5. *Operculina turpethum* (Linn.) Manso (=*Ipomoea turpethum* R. Br.)	See *Ipomoea*

Families and active principles	Names of plants	General remarks
57. *Solanaceae*— (Datura and nightshade Family)	1. *Atropa belladonna* Linn.	Fatal cases of poisoning reported; dryness of mouth and throat, dilation of pupils and delirium characteristic features
	2. *Capsicum annuum* Linn., *C. frutescens* Linn., *C. minimum* Roxb.	Seeds gastro-intestinal irritant; used for torturing
	3. *Datura fastuosa* Linn., *D. metel* Linn., *D. stramonium* Linn.	Commonly used by criminals for stupefying their victims, symptoms resemble those of atropa
	4. *Hyoscyamus muticus* Linn., *H. niger* Linn., *H. pusillus* Linn., *H. reticulatus* Linn.	Cases of livestock and children poisoning on record; action like atropa
	5. *Lycium barbarum* Linn.	Reported poisonous to livestock
	6. *Mandragora caulescens* Clarke	Suspected to be poisonous
	7. *Nicandra physaloides* Gaertn.	Insecticide
	8. *Nicotiana rustica* Linn., *N. tabacum* Linn.	Insecticide, also used to ward off leeches; fatal cases reported among human beings and stock
	9. *Physochlaina praealta* Miers.	Reported poisonous
	10. *Scopolia anomala* (Link et Otto) Airy-Shaw, (*S. lurida* Dunal.)	Poisonous, action like atropa
	11. *Solanum dulcamara* Linn., *S. incanum* Linn. (=*S. coagulans* Forsk) *S. nigrum* Linn. (unripe berries), *S. spirale* Roxb., *S. tuberosum* Linn. (sprouting).	Cases of poisoning among human beings and animals reported, some fatal; gastro-intestonal irritant; occasionally associated with atropa-like symptoms
	12. *Withania somnifera* Dunal	Reported to be used as abortifacient and as an insecticide, stated to be hypnotic

58. *Scrophulariaceae*— (Mimulus and Digitalis Family) Digitalin, digitonin, digitoxin, gitalin, gitonin, *etc.*, saponin, bitter substance	1. *Digitalis purpurea* Linn.	Cardiac poison ; fatal case due to eating of plant reported in India
	2. *Verbascum thapsus* Linn.	Fish poison, seeds narcotic
59. *Bignoniaceae*— (Bignonia Family)	1. *Dolichandrone falcata* Seem.	Fish poisons reputed to be abortifacient
60. *Pedaliaceae*— (Sesamum Family) Sesamol (a phenolic substance), seasamolin	1. *Sesamum orientale* Linn. (=*S. indicum* Linn.)	Seed cakes commonly fed to cattle in India ; stated to be toxic to livestock in Europe producing colic, tremors, dyspnoea and distention
61. *Verbenaceae*— (Verbena and teak Family)	1. *Callicarpa longifolia* Lamk. var. *lunceolaria* C. B. Clarke	Fish poison
	2. *Duranta plumieri* Jacq.	Very bitter and believed to be poisonous to livestock, but generally refused
	3. *Lantana aculeata* Linn. (=*L. camara* Linn.)	Reports about being poisonous to livestock received from the Punjab and Assam Government Departments
	4. *Stachytarpheta jamaicensis* (Linn.), Vahl, var. *indica* H. J. Lam (=*S. indica* Vahl.)	Stated to be abortifacient
	5. *Verbena officinalis* Linn.	Stated to be irritant poison
62. *Labiateae*— (Mint and sage Family) Essential oils, saponins	1. *Eremostachys acanthocalyx* Boiss, *E. vicaryi* Benth.	E. *acanthocalyx* stated to be poisonous ; E. *vicaryi* used as a fish poison
	2. *Lamium amplexicaule* Linn.	Regarded as injurious in America
	3. *Pogostemon heyneanus* Benth. (*P. patchouli* F. B. I., non Pelletier)	Leaves used against insects
63. *Chenopodiaceae*— (Spinach and beet Family) Essential oils, saponins, salsoline, oxalic acid	1. *Chenopodium ambrosioides* Linn., *C. botrys* Linn.	Anthelmintic against hook worm and round worm. Fatal poisoning on record
	2. *Haloxylon recurvum* Bunge ex Boiss., *H. salicornicum* Bunge ex Boiss.	Stated to be poisonous but *H. recurvum* is a favourite food of camels

Families and active principles	Names of plants	General remarks
63. *Chenopodiaceae*—contd.	3. *Salicornia brachiata* Roxb.	Ash stated to be abortifacient
	4. *Salsola kali* Linn.	Suspected poisonous but a feeding test with half dried plants in flowering stage negative
	5. *Suaeda fruticosa* Forsk.	Stated to be poisonous
64. *Phytolaccaceae*— (Phytolacca Family) Bitter substances	1. *Phytolacca latbenia* (Buch-Ham.) H. Walt. (=*P. acinosa* Hook. *f.*, F. B. I., non-Roxb.	Stated poisonous if eaten raw, but it is edible when cooked
65. *Polygonaceae*— (Buck-wheat and rhubarb Family) Rutin, essential oils, anthra-quinone derivatives, oxalic acid, oxalates	1. *Fagopyrum esculentum* Moench, *F. tataricum* Gaertn.	Commonly eaten but under certain conditions, not properly understood at present, produces eruptions and urticaria
	2. *Polygonum aviculare* Linn., *P. flaccidum* Meissn), *P. hydropiper* Linn., *P. orientale* Linn., *P. persicaria* Linn., *P. tomentosum* Willd.	*P. hydropiper* biting to a degree that no animal will eat it. Acrid, emetic, vesicant, insecticidal and piscicidal properties to varying degree strongly suspected
	3. *Rheum emodi* Wall., and probably some others	Petiole edible and so also the leaves, but latter responsible for occasional poisoning
	4. *Rumex acerosa* Linn., *R. acetosalla* Linn.	Oxalic acid poisoning if eaten in excess
66. *Aristolochiaceae*— (Birth-wort Family) Aristolochin, glucoside, essential oils, bitter substance	1. *Aristolochia bracteata* Retz., *A. indica* Linn.	Nauseous and bitter, emmenagogue and abortifacient ; *A. bracteata* insecticide
67. *Piperaceae*— (Pepper Family) Essential oils, piperine, piperovatine	1. *Piper* sp.	Harmful effects of *P. betle* Linn., *P. nigrum* Linn. well known

68. *Myristicaceae*— (Nutmeg Family) Essential oil (with myristicin), saponins	1. *Myristica fragrans* Houtt., *M. malabarica* Lamk., possibly some others also.	Narcotic ; occasional cases of poisoning reported
69. *Lauraceae*— (Laurel Family) Essential oils	1. *Cassytha filiformis* Linn.	Stated to be used as insecticide
	2. *Cinnamomum camphora* F. Nees (product imported)	Protective against moths ; counter-irritant, systemically stimulates then depresses and paralyses central nervous system
70. *Thymeliaceae*— (Mezereum Family) Saponins	1. *Daphne cannabina* Wall., *D. oleoides* Schreb.	Severe gastro-intestinal irritant, camels do not eat *D. oleoides*
	2. *Edgeworthia gardneri* Meissn.	Fish poison
	3. *Lasiosiphon eriocephalus* Dcne.	Dust from dried plant very irritant, not eaten by livestock, fish poison
	4. *Wikstroemia viridiflora* Meissn. (*W. indica* C. A. Mey, var. *viridiflora* Hook. *f.*)	Fish poison
71. *Loranthaceae*— (Mistletoe Family)	1. *Viscum* sp. and possibly others	Poisonous properties probably acquired if growing on poisonous hosts, e.g. *Strychnos nux-vomica*
72. *Euphorbiaceae*— (Croton and castor oil Family)	1. *Andrachne cordifolia* Muell.-Arg.	Cattle poisoning reported, African species used as insecticide
Cyanogenetic compounds, saponins, crotonoside, ricinine, essential oils, euphorbon, phenolic substance, resins, toxalbumins	2. *Baliospermum montanum* Muell., Arg. (=*B. axillare* Blume.)	Seeds and oil drastic purgative, seeds in overdoses acro-narcotic poison
	3. *Buxus sempervirens* Linn.	Stated to be fatal to camels and cattle ; goats probably immune
	4. *Chrozophora rottleri* A. Juss ex Spreng. (=*C. tinctoria* Hook. *f.* in part)	Emetic and cathartic ; animals avoid it
	5. *Cleistanthus collinus* Benth. & Hook. *f.*	Used as fish poison and occasionally as human poison, extract violent gastro-intestinal irritant
	6. *Croton oblongifolius* Roxb., *C. tiglium* Linn.	Seeds especially and the oil also drastic purgative ; poisoning reported ; seeds stated to be used as insecticide and piscicide

Families and active principles	Names of plants	General remarks
72. *Euphorbiaceae*—contd.	7. *Euphorbia acaulis* Roxb., *E. antiquorum* Linn., *E. cattimandoo* W. Elliot, *E. helioscopia* Linn., *E. hirta* Linn., *E. hypericifolia*, *E. neriifolia* Linn., *E. nivulea* Buch.-Ham., *E. peplus* Linn., *E. pilosa* Linn., *E. rothiana* Spreng., *E. royleana* Boiss., *E. thomsoniana* Boiss., *E. thymifolia* Linn., *E. tirucalli* Linn., *E. trigona* Haw	Acrid and vesicant juice in most species ; some used as abortifacient when applied locally ; *E. antiquorum*, *E. neriifolia*, *E. royleana*, *E. tirucalli*, fish poisons ; *E. antiquorum* and *E. thymifolia* stated to be used as insecticides, some poisonous to live-stock
	8. *Excoecaria agallocha* Linn.	Fresh sap extremely acrid, causes intolerable pain if it gets into eye ; woodcutters have suffered, called blinding tree ; fish poison
	9. *Fluggea leucopyrus* Willd., *F. virosa* Baill (=*F. microcarpa* Bl.)	Fish poison, used to destroy worms in sores
	10. *Hura crepitans* Linn.	Seeds and oil violent purgative ; milky juice very irritant
	11. *Jatropha curcas* Linn., *J. glandulifera* Roxb., *J. gossypiifolia* Linn., *J. multifida* Linn.	Violent purgative like *croton* sp., *J. curcas* fish poison
	12. *Manihot utilissima* Pohl.	Fresh tubers extremely poisonous, cassava or tapioca meal specially prepared
	13. *Phyllanthus urinaria* Linn.	Stated to be fish poison
	14. *Ricinus communis* Linn.	Seeds produce violent gastro-enteritis, subcutaneously very poisonous. Oil stated to be an active poison for flies. Plant fish poison
	15. *Sapium indicun* Willd., *S. insigne* Trimen.	*S. indicun* juice narcotic poison ; fruit extremely nauseous, seeds fish poison. *S. insigne* juice vesicant

	16. *Tragia bicolor* Miq., *T. involucrata* Linn. (with varieties)	Stinging nettles
73. *Urticaceae*— (Nettle, hemp and mulberry Family) α-β&γ-antiarin, saponin, resin containing cannabindol (toxic), formic acid	1. *Antiaris toxicaria* Lesch.	Sap used as an arrow poison ; powerful heart poison
	2. *Cannabis sativa* Linn.	The preparations *bhang*, *charas*, and *ganja* well known in India ; excessive indulgence, injurious physically and mentally. Plant stated to be used as a fish poison in Bengal ; spread on beds to drive away bugs
	3. *Ficus* sp.	Some species contain acrid juice ; Watt states fruits of *F. bengalensis* poisonous to horses
	4. *Fleurya interrupta* Gaud	Stings
	5. *Girardinia leschenaultiana* Dcne., *G. zeylanica* Dcne	Stinging nettle
	6. *Laportea crenulata* Gaud., *L. terminalis* Wight	Stinging nettle
	7. *Urtica dioica* Linn., *U. hyperborea* Jacq., *U. parviflora* Roxb., *U. pilulifera* Linn.	Stinging nettle
74. *Juglandaceae*— (Walnut Family)	1. *Juglans regia* Linn.	Rind of unripe fruit stated to be used as fish poison in Jaunsar and Tehri Garhwal
75. *Myricaceae*— (Sweet-gale Family) Essential oils, myricelin	1. *Myrica nagi* Thunb.	Bark stated to be used as fish poison in Khasia hills
76. *Gnetaceae*— (Gnetum Family) Saponins, bitter substance	1. *Gnetum scandens* Roxb.	Fish poison

Families and active principles	Names of plants	General remarks
77. *Coniferea*— (Pine Family) Essential oils, taxine, taxicatin	1. Several members, especially *Taxus baccata* Linn.	Most members possess toxic essential oil and poisoning due to the use of *Juniper oil* as abortifacient reported. Deaths in man and animals due to eating the berries and leaves of *T. baccata* reported ; seeds very poisonous ; fish poison
78. *Iridaceae*— (Iris Family) Saponins, picrocrin (bitter substance) ; essential oils	1. *Crocus sativus* Linn.	Bulbs toxic to young animals ; stigmas in overdoses narcotic poison ; used as abortifacient
79. *Amaryllidaceae*— (Amaryllis and agave Family) Saponin, Lycorine, tazettine	1. *Agave americana* Linn.	Stated as fish poison, also stated toxic to livestock under field conditions, wall paper impregnated with expressed juice said to be proof against white-ants
	2. *Crinum asiaticum* Linn., *C. latifolium* Linn.	Bulbs of *C. asiaticum* strongly emetic and nauseant, those of *C. latifolium* extremely acrid and used for blistering cattle
	3. *Narcissus tazette* Linn.	Bulbous roots emetic and purgative, irritant poison in overdoses
80. *Taccaceae*—	1. *Tacca pinnatifida* Forst.	Tuber intensely bitter, acrid and poisonous when fresh, yields nutritious starch by maceration and repeated washing
81. *Bromeliaceae*— (Pine-apple Family)	1. *Ananas sativus* Schult.	Juice of leaves and unripe fruit purgative and sometimes used as abortifacient

82. *Dioscoreaceae*— (Yam Family) Dioscorine, glucoside (toxic)	1. *Dioscorea bulbifera* Linn., *D. hispida* Dennst. (=*D. daemona* Roxb.), *D. prazeri* Prain & Burk. (=*D. deltoidea* Wall.)	Tubers are very acrid but in most cases boiling, etc. makes them edible.
83. *Liliaceae*— (Lily Family) Imperialine, colchicine, methyl-colchicine, saponine, barbaloin, emodin, sicaloin, resin, essential oils, etc.	1. *Allium sativum* Linn.	Essential oil very irritant and pungent, produces irritant poisoning in excess, also stimulant narcotic, anthelmintic
	2. *Aloe* species	Insipissated juice 'Mushabbar' of commerce powerful drastic purgative; fatal cases reported; used to procure abortion
	3. *Colchicum luteum* Baker	Resembles closely the foreign *C. autumnale* which is poisonous and produces gastro-intestinal irritation; Indian also probably poisonous
	4. *Fritillaria imperialis* Linn.	Bulbs toxic when fresh, said to be a heart poison
	5. *Gloriosa superba* Linn.	Roots stated to be sometimes used for suicidal purposes and as abortifacient, acro-narcotic poison; juice of leaves stated to be used to destroy lice in the hair
	6. *Scilla indica* Baker	....
	7. *Urginia coromandeliana* Hook. *f.*, *U. indica* Kunth.	Bulbs irritant poison. Foreign species *U. scilla* a fish poison; Indian representatives also
84. *Juncaceae*— (Rush Family)	1. *Juncus effusus* Linn.	Suspected poisonous to livestock in South Africa. This and other species in India worth investigating
85. *Palmaceae*— (Palm Family) Arecaine, arecolidine, arecoline, guvacine, guvacoline, saponins	1. *Areca catechu* Linn.	Young and undried nut when chewed in access gives rise to temporary giddiness, also gripping and strong intestinal irritation, sometimes resulting in loose motions

Families and active principles	Names of plants	General remarks
85. *Palmaceae*—contd.	2. *Arenga obtusifolia* Mart.	Juice from fruit used by Malays to poison enemies, *A. obtusifolia* stated to be used as fish poison
	3. *Corypha umbraculifera* Linn.	Fruit stated fish poison
	4. *Wallichia disticha* T. Anders.	Watt states that berries and perhaps the leaves irritate the skin
86. *Araceae*— (Aroid Family) Calcium oxalate (acicular crystals), bitter substance, sharp acrid substance, essential oil (alkaloid and saponin in foreign plant)	1. *Acorus calamus* Linn., *A. gramineus* Soland	Roots stated to be used as effective insecticides and insectifuge. Doubtful case reported when the *A. calamus* proved poisonous to camels during the Afghan Campaign, rhizome a medicine but in overdoses produces a violent and persistent emesis
	2. *Alocasia indica* Schott, *A. montana* Schott., *A. odora* (Roxb.) C. Koch (=*A. macrorrhiza* Schott)	Fresh tubers acrid and irritant
	3. *Amorphophallus campanulatus* (Roxb.) Bl., *A. lyratus* Engl., *A. sylvaticus* (Roxb.) Kunth (*Synantherias sylvatica* Schott.)	Fresh tubers acrid and irritant ; seeds intensely acrid. Seeds of *A. sylvaticus*, like *Plesmonium*, and fruit intensely acrid
	4. *Arisaema speciosum* Mart., *A. tortuosum* Schott.	Tubers poisonous, insecticidal, fruit also probably poisonous
	5. *Homalomena rubescens* Kunth	Stated to be poisonous
	6. *Lagenandra ovata* (Linn.) Thw. (=*L. toxicaria* Dalz.)	Stated to be very poisonous ; also insecticidal
	7. *Plesmonium margaritiferum* Schott.	Crushed seeds produce local anaesthesia ; used as a cure for toothache
	8. *Sauromatum guttatum* Schott.	Tubers regarded as very poisonous

	9. *Steudnera virosa* (Kunth) Prain (= *Colocasia virosa* Kunth)	Poisonous
	10. *Thomsonia nepalensis* Wall.	Acrid when fresh
	11. *Typhonium trilobatum* (Linn.) Schott.	Fresh tubers exceedingly acrid
87. *Cyperaceae*— (Sedge Family) Essential oil	1. *Carex cernua* Boott.	Said to be one of the causes of 'vlei' poisoning in cattle in South Africa
	2. *Cyperus longus* Linn.	Regarded as poisonous in South Africa
	3. *Scirpus corymbosus* Heyne.	See *Carex cernua*
88. *Gramineae*— (Grass Family) Cyanogenetic glucosides, hydrocyanic acid, temuline, saponins, oxalic acid, selenium protein (toxic)	1. *Avena fatua* Linn., *A. sativa* Linn.	Good fodder but occasionally deleterious, probably on account of 'hair balls' that are developed in the stomach
	2. *Bambusa arundinacea* Willd.	Fresh young shoots stated to be insecticidal
	3. *Dendrocalamus strictus* (Roxb.) Nees.	Leaves stated to be used to procure abortion
	4. *Lolium perenne* Linn., *L. temulentum* Linn.	Several cases of poisoning, mostly non-fatal in man and animals, from eating the seeds of *L. temulentum*, gastro-intestinal irritation and severe nervous symptoms reported
	5. *Panicum maximum* Jacq.	Suspected to be responsible for the production of 'Dikoor', a disease affecting young sheep in Africa
	6. *Paspalum scrobiculatum* Linn.	Kodra poisoning very similar to *L. temulentum* poisoning, animals suffer much more than men ; animals should be prevented from grazing the crop when ripening

Families and active principles	Names of plants	General remarks
88. *Gramineae*—contd.	7. *Sorghum halepense* (Linn.) Pers., *S. saccharatum* Pers., *S. vulgare* Pers.	Good fodder. Occasional poisoning reported, stunted growth, under drought condition ; frosted leaves, or second growth dangerous
	8. *Stipa* sp. (some)	Believed poisonous ; mechanical action of ' seeds ' may not be overlooked
	9. *Triticum aesativum* Linn.	Under certain conditions deleterious fodder
	10. *Zea Mays* Linn.	Pollen stated to be a possible cause of hay fever, said to be occasionally responsible for deleterious effects, as yet not fully understood

SAMPLING OF SUGARCANE FOR CHEMICAL ANALYSIS

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(With one text-figure)

Introduction

WITH the commencement of the sugarcane research scheme for the Deccan financed by the Imperial Council of Agricultural Research, located at Padegaon, the problem of testing sugarcane varieties was the main item of work, which involved a proper sampling of cane for chemical analysis. On the Manjri Sugarcane Experimental Station, an arbitrary method of sampling for chemical analysis was adopted by taking two random clumps in the main plot (which varied from 4 to 6 *gunthas**). A good deal of difficulty is being experienced at various agricultural stations in India for lack of a proper sampling technique for chemical analysis.

A fairly complete bibliography on the work done by different workers on this subject is given in a recent publication by Narain and Singh in this Journal†. But there is necessity at all stations for undertaking research work which will lead to the best method of sampling for chemical analysis.

It may be mentioned here that at Padegaon, cane is planted in January or February, and is given 34 to 36 irrigations during the 12 months of its growth. During the maturity period from December onwards till February or March, when cane is harvested, the weather remains dry, and is unaffected by frost or rainy weather.

The following terms have been used in this paper :—

(*a*) *Clump sampling.*—This is used to denote the number of canes obtained from a three-eyebud set,

(*b*) ' *Two feet* ' *strip sampling.*—This is used to denote the number of canes obtained from a ' two-feet ' strip, which may consist of a single clump, or two or more clumps.

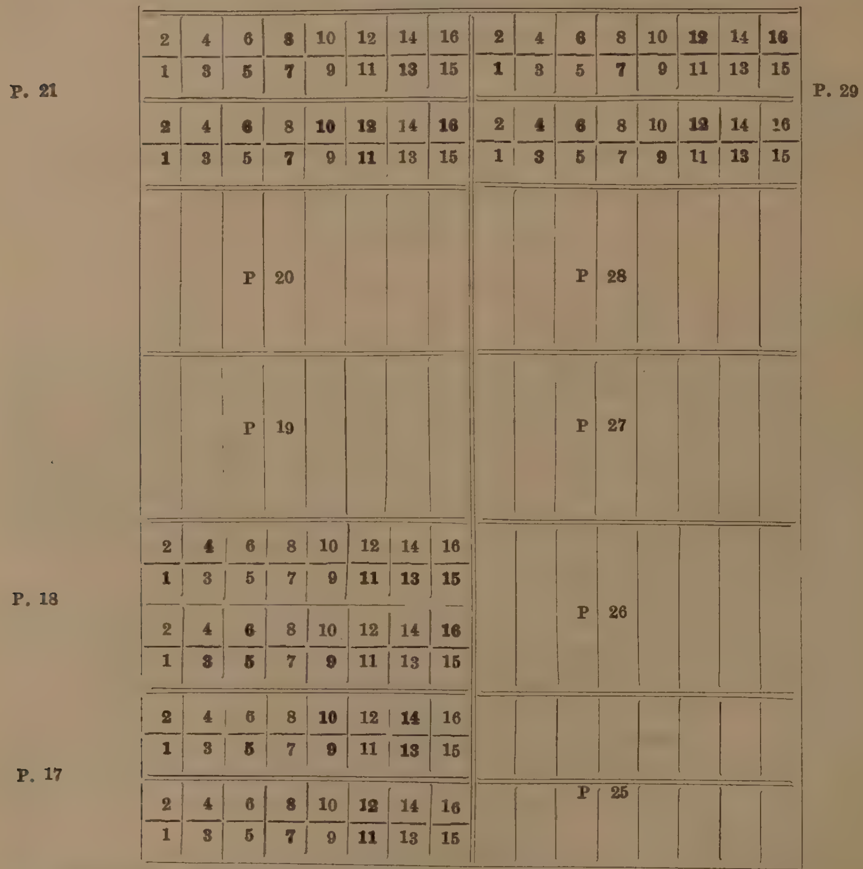
* 1 *guntha* = 1/40 acre

† Vol. 7, part IV

Material

A block of land planted with the variety Co 360 was chosen for the study of sampling for chemical analysis. The cane was planted in February 1934. The total area of the block was 128 cents*, and consisted of 32 plots, each measuring 4 cents (54·44ft. × 32ft.). From these 32 plots, four plots were chosen at random for this work, as shown in the accompanying plan.

Plan showing the location of plots in the block and random spots from where samples were collected



Figures in thick type show the spots in half-portions in a sub-plot (into which a plot is divided) from where samples have been taken.

Duration of work.—The sampling work was carried on for a period of six days — from the 7th to 12th February 1935. The first four days were devoted to clump sampling and the remaining two days for 'two-feet' strip sampling. During the course of the work, extraction tests, as also juice and cane analysis were conducted from day to day, and data with regard to these are presented in Tables I and II :—

*1 cent = 1/100 acre

TABLE I

Extraction of juice (variety Co 360)

Serial No.	Date	Weight of cane in lb.	Weight of juice in lb.	Percentage of extraction	Remarks
1	8 February 1935	2,000	1,296	64·8	
2	8 February 1935	2,000	1,305	65·2	
3	9 February 1935	2,000	1,306	65·3	Extraction tests taken on Chattanuga No. 45 power mill
4	9 February 1935	2,000	1,304	65·2	
5	11 February 1935	1,843	1,198	65·0	
6	11 February 1935	758	490	64·6	
7	12 February 1935	1,129	763	67·6	
8	12 February 1935	1,413	953	67·4	

TABLE II

Analysis of juice and cane (of Table I)

Serial No.	Date	Juice analysis				Cane analysis	
		Brix	Sucrose	Glucose	Purity	Sucrose per cent	Fibre per cent
1	8 February 1935	19·66	173·5	0·50	89·17	14·58	12·90
2	8 February 1935	21·16	19·63	0·33	92·79	16·45	11·42
3	9 February 1935	21·19	20·45	0·18	93·35	16·93	13·81
4	9 February 1935	21·67	20·05	0·28	92·53	17·41	10·50
5	11 February 1935	22·97	21·33	0·32	92·87	18·18	10·80
6	11 February 1935	19·82	17·92	0·68	90·38	16·07	11·98
7	12 February 1935	21·43	19·58	0·49	91·37	16·69	12·61
8	12 February 1935	22·17	20·34	0·34	91·77	17·58	11·01

The power-driven mill used in these tests was Chattanuga No. 45. Similarly, for obtaining juice for analysis of clumps and 'two-feet' strips, the same mill was used.

Statistical examination of the data

Thick figures in the plan indicate the locations or squares from which clumps were taken ; each square was $11\frac{1}{4}$ ft. in length, and squares were taken at random to make up in all 45 clumps from each plot. The number of squares so taken varied from nine to twelve in the four plots taken.

Two-feet strip samples were similarly taken from the squares adjoining the ones from which clumps were taken. The number of two-feet strips taken from each square was four to make up 36 strips per plot.

The data thus consist of 45 clump samples from each of four plots and 36 two-feet strip samples also from each of the same four plots, providing comparison between the two methods of sampling.

For clump sampling, number of canes per clump, average weight per cane, brix and sucrose percentages are calculated and given in the appendix. For two-feet strip samples, similar data were calculated except sucrose percentages.

Number of canes per clump varied between two and eight in two plots, between two and ten in the third plot and between two and nine in the fourth plot. The analyses of variance of the number of canes per clump and average weight per cane are given in Table III.

Table III (*a*)

Number of canes per clump

Due to	Degrees of freedom	Sum of squares	Mean square
Between plots	3	20·33	6·7778
Between clumps and within plots	176	512·22	2·9103
Total (between clumps)	179	532·55	..
Average weight per cane per clump			
Between plots	3	10·7464	3·5821
Between clumps and within plots	176	109·4061	0·6216
Total (between clumps)	179	120·1525	..

TABLE III (*b*)

Two-feet strip sampling

Number of canes per strip

Due to	Degrees of freedom	Sum of squares	Mean square
Between plots	3	26·7986	8·9329
Betweenstrips and within plots	140	489·0278	3·4930
Total (between strips)	143	515·8264	..
Average weight per cane			
Between plots	3	14·0538	4·6846
Between strips and within plots	140	74·3362	0·5310
Total (between strips)	143	88·3900	..

The coefficient of variation for number of canes per clump is 36·80 per cent and number of canes per two-feet strip is 36·54 per cent. Hence there is a high variation in the number of canes per sample which is about the same in both the methods. For the average weight of cane the two methods gave coefficients of variation of 24·22 per cent and 21·98 per cent which were also high.

To study whether there is any correlation between the number of canes per clump or per two-feet strip and average weight per cane the analysis of covariance was worked out and the results are given below :—

TABLE IV (*a*)

Analysis of covariance (clump sampling)

Due to	Degrees of freedom	Sum of products	Mean sum of products
Plots	3	2·8562	0·9521
Within plots	176	−52·4427	−0·2980
Total	179	−49·5865	..

TABLE IV (*b*)

Analysis of covariance (strip sampling)

Due to	Degrees of freedom	Sum of products	Mean sum of products
Plots	3	−5·3856	−1·7952
Within plots	140	−60·7861	−0·4342
Total	143	−66·1717	..

The correlation coefficient after elimination of plot-variance works out to be −0·2215 ($P<0·05$) in clump sampling and −0·3188 ($P<0·05$) in strip sampling. This shows that there is a significant negative correlation, though not very high, between the number of canes per clump and average weight per cane.

Relation between weight and sucrose percentage (clump sampling)

Fig. 1 shows the relationship between total weight of cane and sucrose percentage. There seems to be no correlation between these two factors and this agrees with the conclusions obtained by Davies [1930] working at Trinidad.

The analysis of variance for the data of sucrose percentage (in clump sampling) is as below :—

TABLE V

Analysis of variance (sucrose percentage in clump sampling)

Due to	Degrees of freedom	Sum of squares	Mean square
Between plots	3	121·8810	40·6270
Within plots	176	124·8804	0·7095
Total	179	246·7614	..

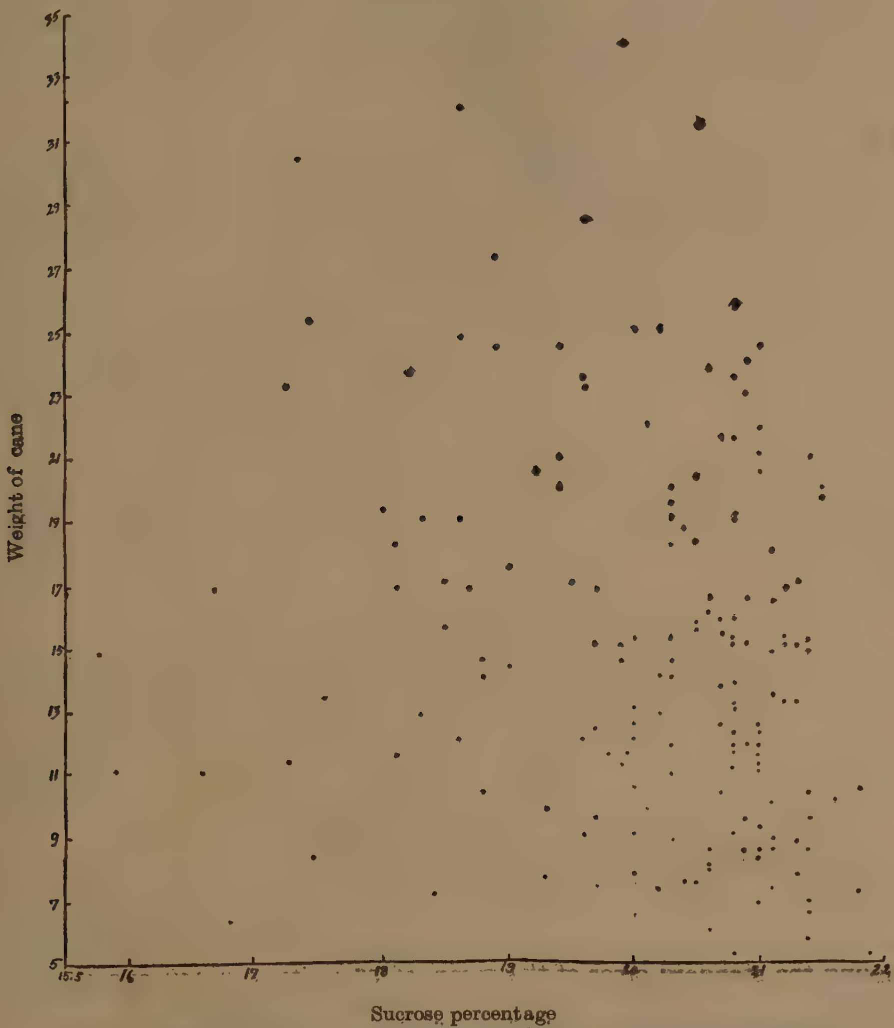


FIG. 1. Weight of cane and sucrose percentage of each of the clumps

The coefficient of variation is 4·17 per cent, which shows that the variation from sample to sample is very small.

Brix sampling

The brix figures are available for both the methods of sampling studied in this paper, and analyses of variance for ' brix ' are given below :—

TABLE VI

(a) Clump sampling

Due to	Degrees of freedom	Sum of squares	Mean square
Between plots	3	82·7135	27·5712
Within plots	176	121·7569	0·6918
Total	179	204·4704	..

(b) Two-feet strip sampling

Due to	Degrees of freedom	Sum of squares	Mean square
Between plots	3	36·5198	12·1733
Within plots	140	99·8934	0·7135
Total	143	136·4132	..

The arithmetic mean, standard deviation and coefficient of variation are shown below :—

(a) Clump sampling		*(b) Two-feet strip sampling*	
Mean	22·02	Mean	22·26
Standard deviation	0·83	Standard deviation	0·84
Coefficient of variation	3·76	Coefficient of variation	3·77

The standard error of the mean of 45 units for clump sampling is 0·123 and this gives an idea of the extent to which the mean is likely to vary from the mean of the entire field. The plot brix mean percentages per clump for the four plots are 22·52, 22·17, 20·87, 22·51. In the case of two-feet strip sampling the standard error of the mean of 36 units is 0·140 and the plot means are 22·71, 21·53, 22·05, 22·74. These show that we may consider that the samples by either method are fairly representative of the field.

Size of the sample for any standard of accuracy

From a knowledge of the extent of variation from sample to sample it is possible to calculate the number of clumps or the number of strips as the case may be which should be taken from a plot in order to measure a difference of say 5 per cent in brix readings and for any standard of accuracy, say at $P=0·05$ or $P=0·01$. This may be calculated easily or read directly from published tables [Vaidyanathan, 1936]. Using these tables for $P=0·05$, we get the number of clumps or the number of two-feet strips to be five for the plots considered, i.e. of area 0·04 acre (the coefficients of variation being about 3·8 per cent in either case).

Similarly for the sucrose percentage which gives a coefficient of variation of 4·17 per cent, the number of samples (clumps) required to measure a 5 per cent difference in sucrose percentage at $P=0\cdot05$ also comes to five.

Summary

Two methods of sampling for chemical analysis have been tried, one on the basis of 45 clumps per plot and the other on the basis of 36 two-feet strips (taken at random). The number of samples required by either method to measure differences of the order of 5 per cent for $P=0\cdot05$ in brix or sucrose percentage have been found to be five.

The extent of variation and correlation between average weight of cane and number of canes per sampling unit by both the methods, and also the correlation between weight of cane and sucrose percentage in the case of clump sampling have been examined.

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Appendix I

Clump sampling

P. No. 29

Sample No.	No. of canes per clump	Average weight per cane	Brix	Sucrose in juice
1	4	3·62	21·94	20·27
2	3	4·33	21·38	19·99
3	7	3·57	21·82	20·16
4	2	5·25	21·64	20·00
5	5	3·00	22·79	20·90
6	5	4·00	20·90	19·40
7	4	3·69	22·87	21·12
8	3	3·25	21·53	20·05
9	3	3·08	22·77	20·96
10	5	3·35	20·77	18·66
11	5	2·65	23·15	21·25
12	4	2·37	23·29	21·40
13	4	2·58	23·35	21·42
14	5	3·35	23·12	21·20
15	5	3·05	22·80	21·17
16	3	3·42	22·50	20·74
17	3	3·83	21·60	19·79
18	4	2·50	23·04	21·14
19	4	3·25	22·54	20·79
20	5	4·20	23·04	21·38
21	6	3·91	22·62	20·84
22	3	2·50	22·23	20·46
23	5	2·10	23·54	21·79
24	3	2·92	23·10	21·33
25	2	3·87	23·22	21·31
26	4	2·81	22·94	21·01
27	6	3·00	22·99	21·12
28	7	3·11	22·74	21·01
29	4	2·19	22·03	20·27
30	3	3·37	23·37	21·64
31	4	2·12	22·70	20·92
32	3	2·58	21·15	19·25
33	6	3·29	23·10	21·49
34	6	1·87	21·55	19·90
35	8	2·50	23·27	21·50
36	7	2·55	22·50	20·76
37	4	4·24	22·97	21·25
38	6	3·16	22·53	20·79
39	6	3·18	22·59	20·79
40	6	2·54	21·98	20·27
41	6	2·46	23·00	21·38
42	4	4·00	22·43	20·61
43	6	1·98	22·67	20·92
44	5	3·00	22·57	20·84
45	5	2·50	22·90	21·04

P. No. 18

Sample No.	No. of canes per clump	Average weight per cane	Brix	Sucrose in juice
1	5	2·32	22·43	19·85
2	5	4·00	22·43	20·34
3	5	3·00	21·78	19·87
4	6	4·75	21·40	19·59
5	7	4·50	22·35	20·46
6	7	3·35	21·29	19·56
7	5	4·10	22·63	20·95
8	4	3·31	22·96	21·21
9	6	3·96	22·30	20·61
10	8	4·58	22·76	20·74
11	2	2·62	22·58	20·84
12	7	3·50	20·69	18·92
13	5	4·95	20·60	18·65
14	5	3·65	22·63	20·45
15	3	4·66	22·09	20·27
16	2	2·50	23·09	21·24
17	3	2·58	21·76	19·98
18	3	3·00	21·89	19·60
19	4	3·62	21·96	19·94
20	8	2·75	21·96	20·07
21	2	4·25	23·26	21·17
22	3	2·42	21·89	20·20
23	4	4·56	22·30	20·34
24	3	4·16	22·63	20·74
25	4	3·12	22·76	20·98
26	8	2·44	21·91	20·30
27	5	2·55	22·13	20·17
28	2	3·25	21·47	19·77
29	5	4·90	20·75	19·42
30	7	4·86	21·67	19·79
31	5	3·00	22·40	21·33
32	6	2·54	21·69	19·82
33	4	2·87	22·98	21·04
34	8	2·87	22·75	20·90
35	3	4·08	23·07	20·82
36	7	3·43	22·80	20·90
37	3	3·92	22·32	20·84
38	5	5·45	20·73	18·93
39	4	4·19	21·60	19·74
40	3	3·75	20·90	18·85
41	4	3·94	22·59	20·73
42	4	3·06	22·73	20·96
43	2	3·00	22·70	20·64
44	4	3·31	23·00	21·16
45	3	5·00	22·90	21·20

P. No. 17

Sample No.	No. of canes per clump	Average weight per cane	Brix	Sucrose in juice
1	8	2·89	21·58	19·59
2	3	2·66	22·53	20·61
3	3	3·16	21·70	19·72
4	5	4·00	22·13	20·30
5	5	3·10	20·38	18·50
6	4	4·25	20·73	18·53
7	5	2·30	20·33	18·10
8	7	2·93	20·16	18·05
9	8	2·12	18·20	15·53
10	7	4·57	20·65	18·58
11	3	4·00	21·62	19·56
12	5	4·30	22·60	20·79
13	5	3·00	21·43	19·67
14	4	3·62	22·10	20·27
15	6	2·00	20·83	18·61
16	4	2·44	21·56	19·32
17	5	2·30	19·76	17·29
18	6	2·83	19·10	16·69
19	4	3·50	20·89	18·81
20	8	3·19	19·94	17·51
21	4	3·19	20·62	18·28
22	3	3·92	22·06	20·25
23	4	2·25	22·09	19·85
24	4	2·81	18·68	16·55
25	6	3·04	20·32	18·11
26	5	2·25	18·61	15·87
27	5	3·50	20·91	18·96
28	8	2·94	19·66	17·32
29	6	3·16	20·96	18·28
30	8	2·62	21·59	19·42
31	4	4·25	21·57	19·53
32	4	3·12	21·73	19·93
33	7	2·75	20·15	17·98
34	6	2·50	18·30	15·76
35	3	4·50	19·62	17·64
36	3	5·50	22·77	20·92
37	5	3·80	22·20	20·27
38	4	3·50	22·39	20·23
39	3	5·25	22·70	20·84
40	4	3·62	20·85	18·76
41	10	2·37	20·59	18·18
42	7	2·71	20·58	18·61
43	2	2·25	20·96	19·12
44	8	2·56	21·00	19·23
45	3	2·83	20·06	17·47

P. No. 21

Sample No.	No. of canes per clump	Average weight per cane	Brix	Sucrose in juice
1	2	2·87	23·06	21·40
2	4	3·34	22·70	21·12
3	2	2·62	23·64	21·91
4	5	3·30	22·60	20·58
5	4	2·25	22·56	20·82
6	4	2·06	23·10	21·04
7	9	2·78	21·91	19·91
8	3	3·87	22·38	20·76
9	2	2·44	22·96	21·06
10	2	3·63	22·34	21·09
11	4	2·50	22·56	20·79
12	6	3·12	22·34	20·39
13	6	1·58	22·87	20·93
14	7	2·91	22·53	20·53
15	5	2·40	21·36	19·74
16	3	2·92	22·24	21·06
17	3	2·83	22·97	20·96
18	3	2·25	22·81	20·96
19	4	3·81	22·89	21·37
20	7	3·68	22·66	20·79
21	4	1·78	20·49	18·44
22	5	2·17	22·12	20·03
23	3	2·50	22·89	20·45
24	3	3·96	22·70	21·01
25	3	2·29	23·07	21·39
26	7	3·50	22·69	20·95
27	6	3·60	22·66	20·74
28	3	4·37	22·52	20·82
29	3	2·83	22·96	21·35
30	4	3·94	22·56	20·53
31	4	1·97	22·71	20·61
32	2	3·62	23·04	21·75
33	3	2·54	22·76	20·93
34	7	1·75	21·32	19·74
35	3	2·42	21·68	19·69
36	4	3·84	22·43	20·66
37	5	2·85	20·76	18·93
38	7	2·21	22·10	20·54
39	8	2·64	22·69	21·01
40	3	2·83	22·31	20·56
41	3	5·08	22·93	20·82
42	4	2·78	22·79	20·84
43	2	3·25	23·31	21·44
44	3	3·66	22·56	21·01
45	5	3·27	22·56	21·06

Appendix II

TWO-FEET STRIP SAMPLING

P. No. 29

Sample No.	No. of canes per strip	Average weight per cane	Brix
1	3	4·75	22·13
2	5	3·20	22·63
3	8	3·67	22·70
4	3	4·66	21·91
5	5	4·30	23·18
6	7	2·82	23·36
7	4	1·44	21·69
8	4	2·75	23·18
9	2	3·00	22·85
10	5	2·42	23·18
11	6	2·46	22·40
12	7	3·78	23·23
13	5	3·90	23·73
14	2	3·75	22·83
15	5	3·35	23·10
16	6	2·29	23·09
17	4	3·75	22·86
18	4	4·53	21·23
19	7	3·34	21·21
20	3	3·33	23·36
21	4	2·22	22·87
22	5	2·20	22·70
23	3	3·00	23·21
24	8	1·86	22·97
25	2	3·62	22·80
26	9	3·11	21·70
27	5	3·00	22·33
28	5	2·50	22·86
29	5	2·47	22·77
30	4	2·75	22·23
31	5	2·27	23·21
32	7	2·18	22·93
33	7	1·78	22·53
34	4	2·56	23·19
35	5	3·30	22·16
36	4	3·28	23·28

P. No. 17

Sample No.	No. of canes per strip	Average weight per cane	Brix
1	7	3·39	20·27
2	6	5·16	22·76
3	5	2·42	22·23
4	4	3·78	22·37
5	6	4·33	21·47
6	6	3·75	22·03
7	8	3·19	22·33
8	6	2·81	22·61
9	6	2·96	21·82
10	7	2·61	22·63
11	5	3·05	22·69
12	4	2·47	21·90
13	4	2·68	20·94
14	2	5·00	21·23
15	8	2·53	20·16
16	8	2·28	22·10
17	4	3·37	20·11
18	7	3·11	21·93
19	5	3·00	23·29
20	5	2·58	21·77
21	5	3·55	21·00
22	7	2·21	19·66
23	12	2·85	19·96
24	8	2·94	24·03
25	4	3·75	21·77
26	3	3·37	22·98
27	8	3·62	23·13
28	5	3·25	22·17
29	6	3·77	20·91
30	7	4·30	21·00
31	4	3·25	21·26
32	8	2·45	19·13
33	6	2·50	19·76
34	7	3·07	19·82
35	5	1·95	20·55
36	2	4·12	21·22

P. No. 18

Sample No.	No. of canes per strip	Average weight per cane	Brix
1	4	3·50	21·63
2	4	3·50	23·27
3	6	3·17	22·60
4	2	5·50	22·33
5	4	4·00	20·66
6	5	3·60	22·00
7	6	4·92	22·27
8	6	4·00	21·83
9	4	4·25	20·92
10	7	3·14	22·00
11	9	2·44	21·90
12	5	4·00	22·23
13	3	4·33	22·49
14	3	3·00	22·69
15	3	4·17	21·00
16	4	2·62	21·06
17	5	5·50	22·59
18	7	3·43	22·23
19	6	4·25	22·53
20	4	3·75	21·60
21	5	4·60	22·96
22	3	4·33	23·17
23	3	4·67	22·26
24	5	3·40	19·20
25	7	3·37	22·76
26	2	3·50	22·59
27	6	3·58	22·66
28	4	4·50	19·66
29	4	3·50	21·93
30	2	4·50	22·43
31	5	2·80	22·93
32	9	3·67	22·86
33	6	4·00	22·86
34	3	3·50	23·04
35	4	3·62	22·39
36	8	4·06	20·42

P. No. 21

Sample No.	No. of canes per strip	Average weight per cane	Brix
1	5	3·80	22·90
2	4	3·12	22·99
3	5	2·94	22·97
4	4	2·38	23·43
5	8	2·44	22·70
6	3	3·50	22·80
7	4	3·62	22·80
8	4	3·62	23·29
9	8	3·44	23·43
10	6	2·42	22·63
11	4	3·37	23·06
12	9	3·33	22·60
13	5	3·50	22·13
14	3	2·83	23·11
15	4	2·25	22·88
16	6	2·83	22·01
17	5	2·20	22·83
18	3	3·67	21·76
19	3	4·67	22·67
20	2	3·50	22·93
21	3	3·00	21·69
22	4	3·25	23·06
23	4	3·00	23·10
24	3	3·66	23·29
25	4	3·75	22·35
26	6	3·42	22·73
27	3	3·67	23·24
28	4	3·00	22·43
29	9	2·67	22·46
30	4	4·00	22·84
31	4	1·88	21·96
32	3	4·33	22·26
33	4	3·50	22·99
34	7	3·29	23·10
35	8	2·19	22·66
36	5	2·60	22·63

STUDIES ON INDIAN RED SOILS

I. BUFFER CURVES AND BASE-EXCHANGE REACTIONS

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Introduction

As yet there is no satisfactory method of classifying the red soils which occur in different parts of India. They are often designated as laterites or lateritic, irrespective of their physico-chemical properties. The present paper aims at classifying some of the typical red soils in India from studies of base-exchange properties of the soils including the study of buffer curves and of total exchangeable bases and the percentage base saturation. The changes in the water-holding capacities and percentages of imbibitional water of the soils after saturation with lime at *p*H 7·1 have also been studied.

Experiments and results

A. Buffer curves

(*a*) *Determination of buffer curves.*—The determination of lime-requirements of soils at different *p*H values and the examination of the buffer curves were carried out by following essentially the method devised by Schofield [1933]. The principles of this method are : (*a*) that the solution of an acid has maximum buffer action at its half neutralized stage, and (*b*) that if a soil be shaken with a mixture of lime and an organic acid whose calcium salt is soluble, the soil will take up base from the solution or give up base to the solution depending on the relative differences in the *p*H values between the soil and the solution. Hence by shaking a weighed quantity of a soil with a mixture of lime and the organic acid, we can bring the acid to the half-neutralized stage. If the amount of base-uptake be plotted as abscissa and the corresponding *p*H values as the ordinate, the characteristic buffer curve of a soil would be that which passes through the plotted points on the curve.

The organic acids which were used in these determinations and their *p*H values at half neutralized points are as follows :—

Name of acids	*Formula*	*pH at half neutralized point*
Monochlor acetic	$CH_2Cl.COOH$	2.9
Acetic	CH_3COOH	4·6
p-nitrophenol	$C_6H_4(NO_2)OH$	7·1
Phenol	C_6H_5OH	9·8

The uptake of bases at *p*H 1·3 and 12·5 were determined by treating the soils with 0·05 *N* hydrochloric acid and 0·04 *N* barium hydroxide respectively

(b) *Determination of* pH.—The pH values were obtained at soil : water ratio of 1 : 2·5 by Kuhn's barium sulphate method and a Hellige colorimeter.

(c) *Determination of percentage carbonate contents.*—The carbonate contents of soils were determined by Collin's calcimeter.

(d) *Determination of saturation capacity at* pH *7·0.*—The saturation capacities at pH 7·0 were determined by the barium-acetate-ammonium-chloride method of Parker [1929].

(e) *Determination of total exchangeable bases.*—The total exchangeable bases of the soils were determined by the method of William [1929]. The observed figures of exchangeable bases were corrected for the carbonate contents of the soils, wherever the soil contained measurable amounts of carbonate. Since the carbonate contents of the soils were never very large, such a correction was thought to be justifiable. A blank determination using no soil was made in order to correct for the exchangeable bases in the reagents and in the filter paper employed.

(f) *Determination of exchangeable calcium.*—The method of determining exchangeable calcium was essentially that used by Williams [1929]. The observed figures of exchangeable calcium were corrected for the carbonate figures. Here again since the percentage of carbonate in the soils was in all cases quite low, such a correction was thought to be justifiable.

Results and discussions

A. Buffer curves

The data on the uptake of base at different pH values are shown in Table I.

TABLE I

Milli equivalent base taken up by 100 gm. of over-dry soil

Lab. No.	pH 1·3	pH 2·9	pH 4·6	pH 7·1	pH 9·8	pH 12·5	Fig. No.
1p	—4·0	—1·8	1·2	5·6	15·4	21·5	1
2p	—4·2	—2·0	3·7	8·6	21·3	29·7	1
3p	—7·9	—2·9	3·2	7·4	21·0	30·6	1
4p	—1·7	—0·6	0·9	2·7	7·6	10·9	2
5p	—5·8	—1·9	0·7	3·4	11·0	16·4	2
6p	—11·1	—5·4	—1·3	3·3	15·2	25·0	2
7p	—17·6	—13·2	—9·1	—2·1	5·6	13·8	2
8p	—5·5	—2·5	—0·9	0·9	4·0	7·3	
10p	—34·2	—15·9	—3·9	4·4	19·7	31·3	3
11p	—18·6	—10·8	—3·1	2·6	18·1	31·7	3
12p	—12·8	—8·0	—2·9	1·6	13·6	24·9	3
14p	—6·1	—3·0	—0·7	3·1	15·1	22·3	
18p	—9·6	—4·3	—2·5	1·3	6·7	12·7	4
19p	—23·4	—6·6	—1·5	2·6	13·7	24·7	4
20p	—30·9	—5·9	—1·7	1·3	4·4	15·1	4

TABLE I—*contd.*

Lab. No.	pH 1·3	pH 2·9	pH 4·6	pH 7·1	pH 9·8	pH 12·5	Fig. No.
23p	—36·4	—16·8	—5·5	5·4	35·8	58·5	
24p	—38·9	—17·6	—5·3	7·0	39·8	78·9	
25p	—59·3	—17·6	—6·0	1·4	28·8	36·9	
26p	—85·0	—21·8	—4·8	1·5	27·2	60·2	
27p	—76·6	—12·4	—3·5	2·1	20·9	40·0	
33p	—6·0	—2·6	—0·9	3·8	14·0	22·5	5
34p	—10·1	—4·4	—1·4	6·5	20·3	29·8	5
35p	—13·7	—5·6	—2·8	3·9	17·1	27·5	5
42p	—10·3	—5·9	—2·5	1·7	7·8	13·2	
43p	—16·0	—6·2	—2·6	2·1	13·5	22·8	
45p	—10·3	—3·3	—2·1	4·2	17·6	24·8	
46p	—13·8	—4·8	—4·6	2·7	16·3	24·5	
48p	—1·9	—0·6	0·0	1·3	4·5	6·8	
49p	—5·6	—1·7	—0·6	1·3	8·1	9·4	
50p	—7·7	—1·1	—0·4	0·7	6·1	13·0	
51p	—11·8	—2·3	—0·9	0·0	5·7	16·8	
53p	—26·8	—15·4	—7·2	0·4	13·2	27·4	6
54p	—18·1	—5·8	—1·8	1·7	13·5	25·0	6
55p	—28·9	—5·5	—1·5	1·3	14·0	25·9	6
56p	—10·0	—5·9	—1·8	10·2	33·1	41·1	7
57p	—7·5	—3·0	—0·5	10·2	32·5	41·2	7
58p	—8·5	—4·9	—1·9	6·0	25·2	37·1	7
59p	—7·1	—2·8	1·9	16·4	59·8	..	
60p	—7·7	—4·9	—3·3	6·0	27·4	36·5	8
61p	—11·5	—7·3	—4·6	5·6	28·4	39·2	8
62p	—12·1	—6·4	—2·5	6·9	25·5	38·1	8
63p	—12·2	—5·5	—2·2	3·8	19·6	32·3	
64p	—8·6	—3·9	—1·8	1·3	10·8	18·0	
65p	—23·0	—14·3	—7·8	—1·3	4·6	19·3	
67p	—33·2	—18·0	—13·4	—2·3	6·5	19·3	
68p	—41·5	—17·2	—7·9	—0·5	11·7	31·9	
70p	—4·8	—1·8	0·3	4·5	16·1	23·2	
71p	—5·3	—1·6	0·5	5·0	16·8	19·9	
73p	—8·7	—4·4	—2·8	1·7	12·3	19·9	
74p	—7·3	—2·2	—1·1	1·3	12·3	20·3	

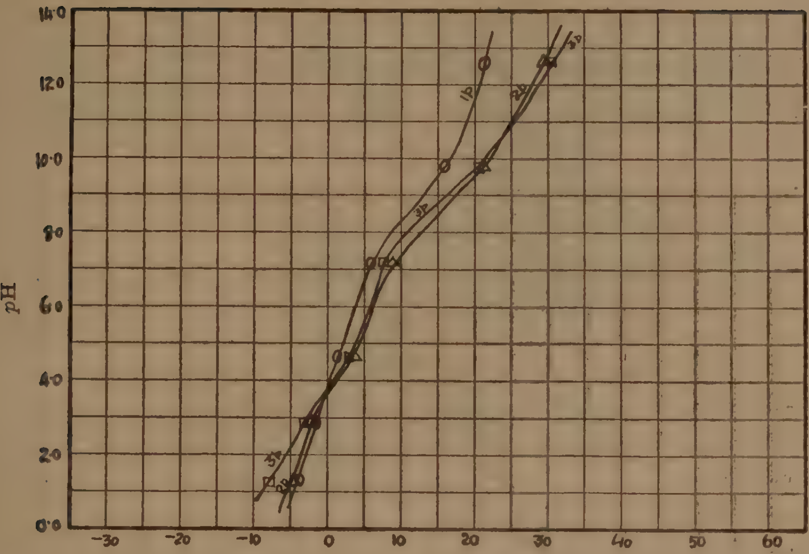

FIG. 1. Milli equivalent base taken up by 100 gm. oven-dry soil (Dacca, Bengal)

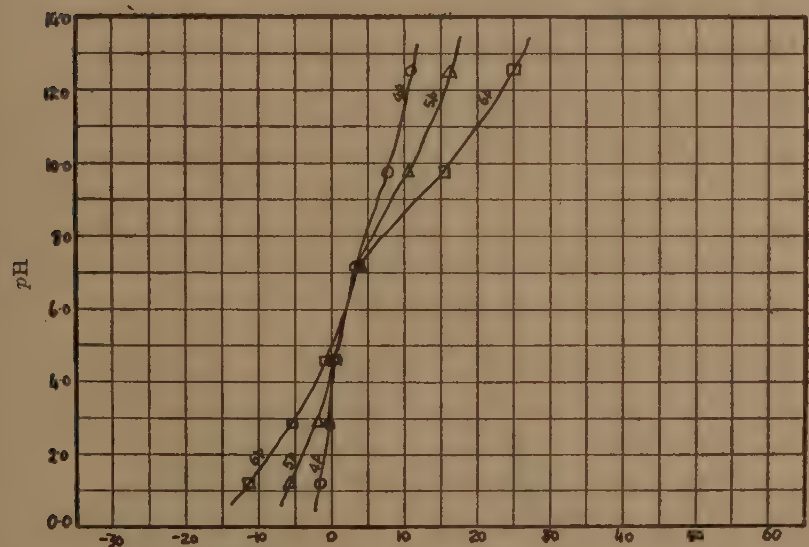

FIG. 2. Milli equivalent base taken up by 100 gm. oven-dry soil (Suri, Bengal)

As typical examples of the nature of the buffer curves, those of the samples from Dacca (Bengal), Suri (Bengal), Bidar (Hyderabad), Himayatsagar (Hyderabad), Raipur (C. P.), and Nilgiri Hills (Madras), are shown in Figs. 1-5. It will be noticed that almost all the curves indicate a more or less definite

inflexion at pH 9·8 and a second inflexion either at pH 2·9 or at pH 4·6. It was felt desirable to determine the buffer values ($\beta = \frac{\Delta B}{\Delta pH}$) at pH's 2·9, 4·6 and 9·8 from the buffer curves. Table II shows the calculated buffer values.

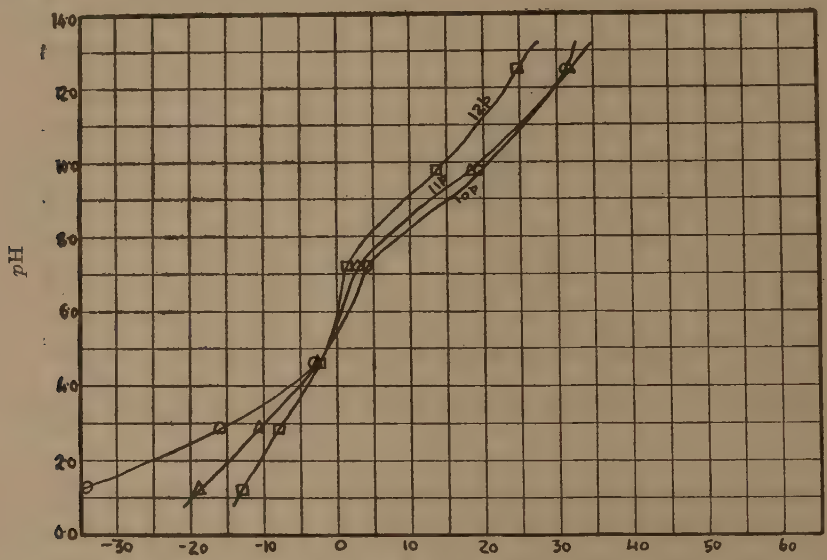

FIG. 3. Milli equivalent base taken up by 100 gm. oven-dry soil (Bidar, Hyderabad)

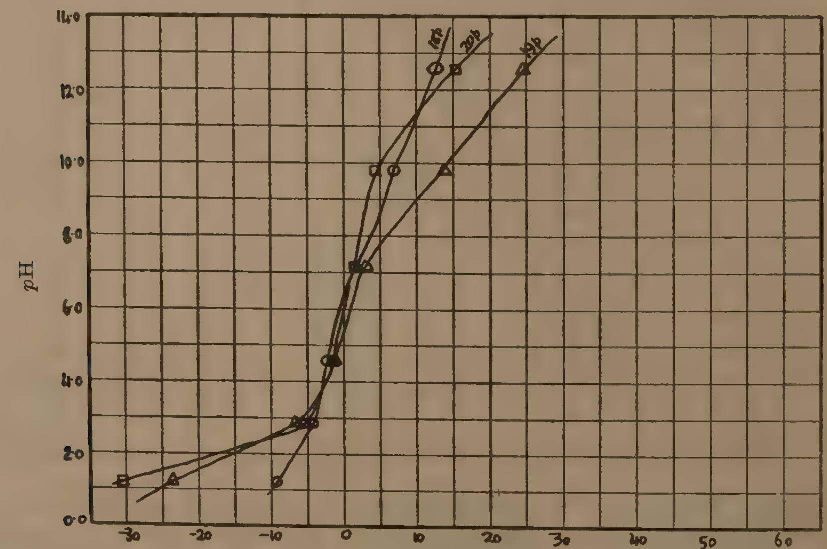

FIG. 4. Milli equivalent base taken up by 100 gm. oven-dry soil (Himayatsagar, Hyderabad)

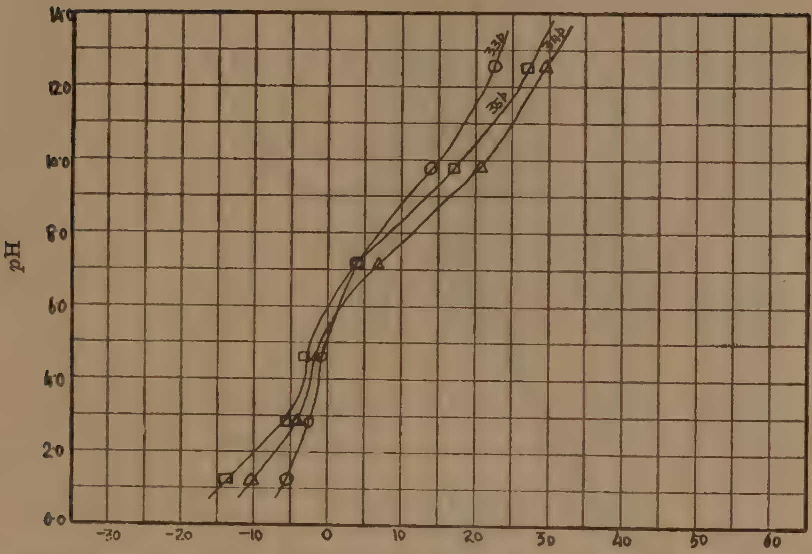

FIG. 5. Milli equivalent base taken up by 100 gm. oven-dry soil (Raipur, C. P.)

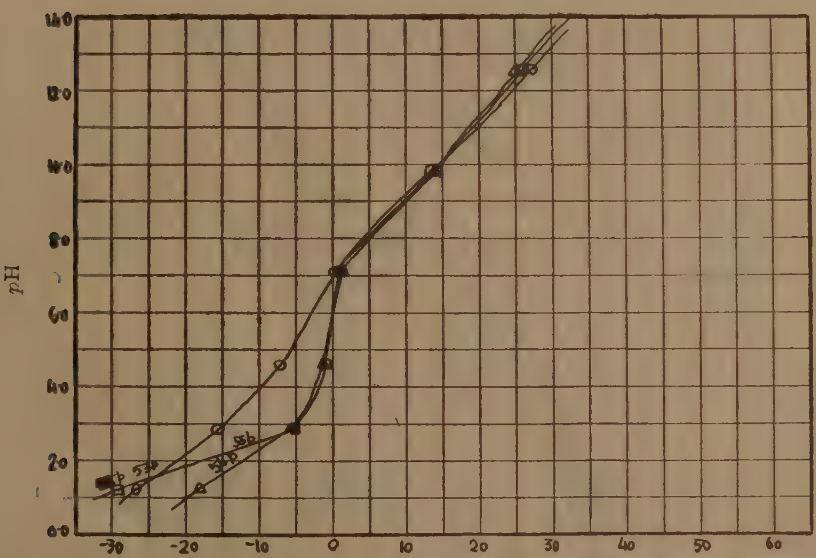

FIG. 6. Milli equivalent base taken up by 100 gm. oven-dry soil (Nilgiri Hills, Madras, 3,000 ft. above sea-level)

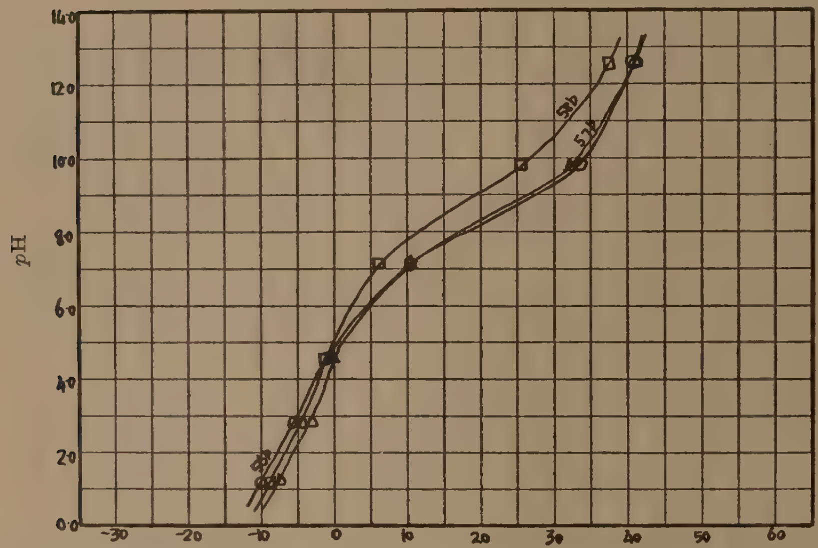

FIG. 7. Milli equivalent base taken up by 100 gm. oven-dry soil (Nilgiri Hills, Madras, 5,000 ft. above sea-level)

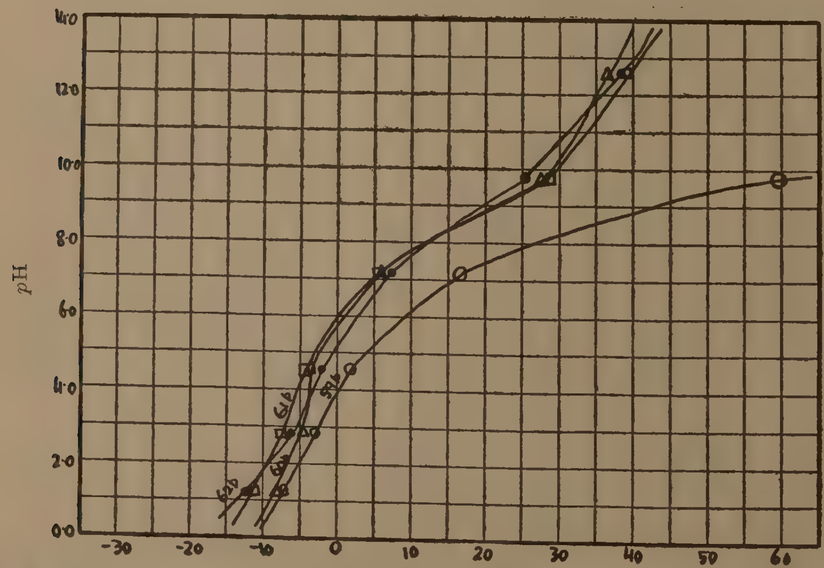

FIG. 8. Milli equivalent base taken up by 100 gm. oven-dry soil (Nilgiri Hills, Madras, 7,000 ft. above sea-level)

TABLE II

Locality	Lab. No.	Depth	pH 2·9	pH 4·6	pH 9·8
Dacca Farm, Bengal	1p	0 in.—6 in.	0·0015	0·0018	0·0038
	2p	6 in.—2 ft. 3 in.	0·0018	0·0032	0·0041
	3p	2 ft. 3 in.—4 ft.	0·0033	0·0030	0·0053
Suri, Birbhum, Bengal	4p	0 in.—1 ft.	0·0010	0·0010	0·0020
	5p	1 ft.—1 ft. 6 in.	0·0020	0·0015	0·0030
	6p	1 ft. 6 in.—4 ft.	0·0034	0·0021	0·0052
Bidar, Hyderabad	10p	0 in.—1 ft.	0·0087	0·0047	0·0063
	11p	1 ft.—3 ft.	0·0047	0·0035	0·0063
	12p	3 ft.—4 ft.	0·0033	0·0025	0·0060
Himayatsagar, Hyderabad	18p	0 in.—3 in.	0·0023	0·0007	0·0017
	19p	3 in.—1 ft. 6 in.	0·0067	0·0010	0·0043
	20p	1 ft. 6 in.—4 ft.	0·0070	0·0007	0·0027
Raipur, Central Provinces	33p	0 in.— 4 in.	0·0015	0·0005	0·0040
	34p	4 in.—1 ft. 5 in.	0·0030	0·0010	0·0048
	35p	1 ft. 5 in.—4 ft.	0·0030	0·0010	0·0053
Nilgiri Hills (3,000 ft. above sea-levels) (1)	53p	0 in.—1 ft. 8 in.	0·0060	0·0040	0·0046
	54p	1 ft. 8 in.—3 ft.	0·0047	0·0017	0·0043
	55p	below 54p	0·0042	0·0013	0·0048
Nilgiri Hills (5,000 ft. above sea-levels) (2)	56p	0 in.—1 ft.	0·0023	0·0026	0·0038
	57p	1 ft.—2 ft.	0·0020	0·0015	0·0040
	58p	2 ft. 6 in.—6 ft.	0·0020	0·0017	0·0043
Nilgiri Hills (7,000 ft. above sea-levels) (3)	59p	0 in—1 ft.	0·0028	0·0027	..
	60p	1 ft.—3 ft.	0·0030	0·0022	0·0047
	61p	3 ft.—4 ft. 6 in.	0·0021	0·0015	0·0040
	62p	4 ft. 6 in.—6 ft.	0·0013	0·0010	0·0037

No regular variation of $\frac{\Delta B}{\Delta pH}$ down the soil profiles is observed. In some cases the manner of variation of $\frac{\Delta B}{\Delta pH}$ at the three pH values is not the same.

Within certain limits of variation, however (approximately 10 per cent), it is possible to classify the soil profiles into four divisions :

1. Increase* of $\frac{\Delta B}{\Delta pH}$ down the profile : Dacca, Suri and Raipur.

2. Decrease* of $\frac{\Delta B}{\Delta pH}$ down the profile : Bidar (Hyderabad), Nilgiri Hills (1) and Nilgiri Hills (3).

*An average of the variation of $\frac{\Delta B}{\Delta pH}$ at the three pH values, 2·9, 4·6 and 9·8, is noted.

3. Maximum value* of $\frac{\Delta B}{\Delta pH}$ at an intermediate depth : Himayatsagar (Hyderabad).

4. Value of $\frac{\Delta B}{\Delta pH}$ is fairly constant* down the profile : Nilgiri Hills (2).

Mention may be made here of the work of Anderson and Byers [1936] who have found that the character of neutralization curves made with sodium hydroxide varies widely for colloids of different soil groups. The colloids of Pedocal soils show the strongest acid character. The colloids of the lateritic soils have much weaker acid qualities than those of the Pedocal soils, and their titration curves are of such markedly different form that the two groups are readily differentiated by this means. The Prairie group and the Gray-Brown Podzolic group have titration curves intermediate in character between those of the Pedocal and the lateritic soils. The Pedocal soil colloids require about 0·55 milli equivalent per gm. to reach the neutral point (pH 7), those from the Prairie soils just a little less, approximately 0·5, and the Gray-Brown Podzolic group covers the range from nearly 0·5 to about 0·2, which is near the maximum quantity required by the lateritic colloid.

Puri and Asghar [1938] have performed electrometric titrations of soils after removing from them exchangeable bases by leaching the soils with 0·05 *N* hydrochloric acid and using glass electrode for measuring the pH values.

In our present investigations we have used natural soils with no pretreatment, since Schofield's procedure of obtaining buffer curves is obviously suitable for working directly with natural soils.

In a series of publications on the potentiometric and conductometric titrations of silicic acid sols, humic acid sols and acid clays, Mukherjee, and coworkers have been investigating as to whether the classical treatment of electrochemical equilibria is sufficient for an adequate representation of the properties of these substances (for a review of this series of publications, see Mukherjee, Mittra and Mukherjee [1937]) . They have shown that electrometric titration curves usually afford valuable information regarding the total acidities, dissociation constants, and basicity of acids or mixtures of acids in true solutions. But when the solid phase is present, the interpretation is not as simple. Mention may also be made of the work of Bradfield [1924] who has shown that the manner of variation of pH of electrodialysed clay with its concentration is of the same nature as that of a weak acid, like acetic acid, and has thus concluded that the colloidal fraction of an acid soil can itself be considered to be an acid which ionizes to produce a definite Sorensen value and show a definite titratable acidity or normality on titration with strong bases. Puri and Asghar [1938] have also concluded from their results that the titration curves of soil acidoids closely resemble those of weak dibasic acids. It may also be interesting to note that Puri has defined the terms exchangeable bases, exchangeable hydrogen, base-exchange capacity and saturation capacity in

*An average of the variation of $\frac{\Delta B}{\Delta pH}$ at the three pH values, 2·9, 4·6 and 9·8, is noted.

terms of the acidoid equivalent of the soil samples, thus giving an interpretation to these terms which bears no reference to any particular method of estimating these quantities.

Attempt at a discussion of the nature of buffer curves on the same lines as the electrometric titration curves would be, at this stage of our knowledge, quite premature. The study of the buffer curves has, however, an interesting feature. Different soils have different but specific constituents with specific buffer capacities. It is suggestive, therefore, that for characterizing the soil types from the point of view of soil survey, the study of buffer curves might be of interest and of significant importance.

It is difficult to suggest the significance of the inflexions of the buffer curves at pH's 2·9, 4·6 and 9·8 and the problem is under investigation. Mention may be made here of the potentiometric titrations of sodium silicate solutions with hydrochloric acid carried out by Joseph and Oakley [1925], Harman [1927], Britton [1927] and with sulphuric acid by Krestinskaja and Moltschanowa [1936]. The results of these investigations show an inflexion near about pH 11·0, which indicates a definite stage of neutralization at this pH. This inflexion has been supposed by Harman to correspond to the formation of acid silicate ($NaHSiO_3$).

Krestinskaja and Moltschanowa, on the other hand, conclude that the inflexion at pH 11·0 represents the neutralization of hydroxyl ions produced by the hydrolysis of sodium silicate :

$$SiO_3'' + H_2O \leftrightarrows HSiO_3' + OH'$$

Harman and Britton have observed a second inflexion between pH's 5 and 6. They regard this second inflexion to represent the complete liberation of silicic acid whilst Krestinskaja and Moltschanowa consider the second inflexion to represent the neutralization of the hydroxyl ions derived from the hydrolysis of the acid silicate :

$$HSiO_3' + H_2O \leftrightarrows H_2SiO_3 + OH'$$

Krestinskaja and Moltschanowa also observed a third inflexion at pH 4·5, which they suggest might be due to the decomposition of a complex silicate stable in the acid region.

Since in the composition of soils silicates predominate, it is quite possible that the inflexion points in the buffer curves of soils might be analogous to those observed in the case of potentiometric titration curves of sodium silicate solutions. The free alumina present in the soil samples probably also play an important role in determining the nature of the buffer curves.

B. Experiments with electrodialysed soils

The soil samples 53p—55p from the Nilgiri Hills were electrodialysed * and the buffer curves of the soils are shown in Fig. 9.

Regarding the nature of the buffer curves of the electrodialysed soils it is found that up to about pH 7·1, all the curves are almost linear. The curves

*The process of electrodialysis was carried out in a 3-chambered electrodialysis vessel of Pauli's pattern. The soil was kept in the middle chamber and electrodialysis was carried out until the liquid at the cathode was neutral.

for the electrodialysed soils 53p and 55p show an inflexion at pH 9·8, whilst that for 54p does not. This behaviour of the soils is indeed very striking in comparison with the behaviour of the same soils, unelectrodialysed, which show an exactly opposite behaviour.

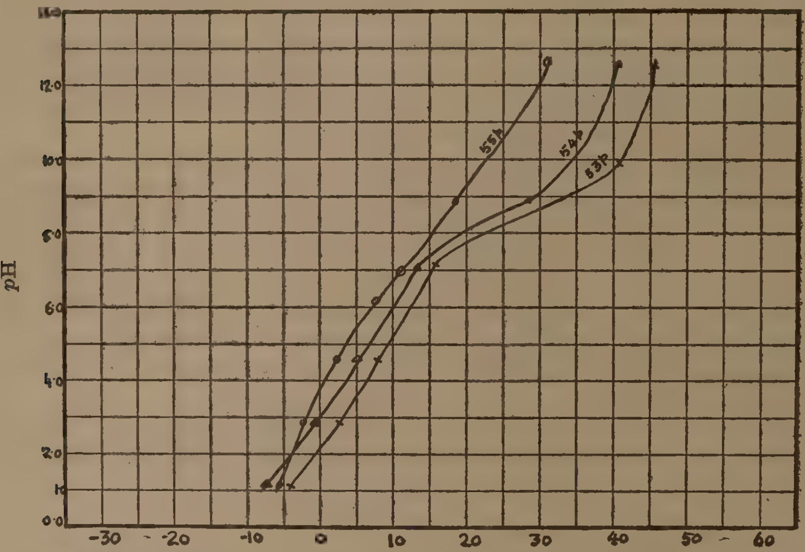

FIG. 9. Milli equivalent base taken up by 100 gm. oven-dry electrodialysed soil (Nilgiri Hills, 3,000 ft. above sea-level)

C. Base-exchange reactions

Table III gives in one place the pH values, the milli equivalent exchangeable bases per 100 gm. oven-dry soil (x), the saturation capacities in milli equivalent base per 100 gm. oven-dry soil (y), percentage base saturation $(\frac{x}{y} \times 100)$, milli equivalent exchangeable calcium per 100 gm. oven-dry soil (z), exchangeable calcium as percentage of total exchangeable bases $(\frac{z}{x} \times 100)$ and finally exchangeable calcium as percentage of total saturation capacity $(\frac{z}{y} \times 100)$.

It will be noticed that in general the percentage base saturation decreases down the following profiles: Dacca and Nilgiri Hills (2). In the case of the profile from Bidar, the percentage base saturation increases with increase in the depth. In the case of the profiles from Suri and Nilgiri Hills (3), the percentage base saturation shows a maximum value at intermediate layers. The Himayatsagar, Raipur and Nilgiri Hills (1) profiles, on the other hand, show a minimum percentage base saturation at intermediate layer.

TABLE III

Locality	Lab. No.	Depth	pH	x	y	$\frac{x}{y}\times 100$	z	$\frac{z}{x}\times 100$	$\frac{z}{y}\times 100$
Dacca Farm, Bengal .	1p	0 in.—6 in.	5·2	2·61	5·6	46·60	1·43	54·96	25·54
	2p	6 in.—2 ft. 3-in.	5·3	3·63	8·35	43·38	1·22	33·70	14·61
	3p	2 ft. 3 in.—4 ft.	5·2	4·69	11·4	41·14	1·63	34·77	14·30
Suri, Birbhum, Bengal	4p	0 in.—1 ft.	5·4	1·39	2·4	56·00	0·67	48·37	27·9
	5p	1 ft.—1 ft. 6 in.	5·4	3·48	5·50	63·27	2·52	64·71	45·8
	6p	1 ft. 6 in.—4 ft.	6·2	7·63	13·90	54·85	4·97	65·22	35·8
Bidar, Hyderabad .	10p	0 in.—1 ft.	6·2	8·38	11·00	76·20	21·10	252·00 (?)	191·9 (?)
	11p	1 ft.—3 ft.	6·2	12·12	14·30	84·75	11·39	93·99	79·7
	12p	3 ft.—4 ft.	6·4	9·5	10·40	91·30	9·02	94·99	86·7
Himayatsagar, Hyderabad.	18p	0 in.—3 in.	6·4	5·46	6·00	91·00	4·38	80·23	74·7
	19p	3 in.—1 ft. 4 in.	6·4	10·04	15·69	64·35	7·46	74·35	47·8
	20p	1 ft. 4 in.—4 ft.	7·3	10·96	13·90	78·82	7·94	72·44	57·1
Raipur, Central Provinces.	33p	0 in.—4 in.	5·8	3·83	4·40	87·07	2·13	55·46	48·4
	34p	4 in.—1 ft. 5 in.	5·8	6·83	9·30	73·33	4·36	63·89	46·9
	35p	1 ft. 5 in.—4 ft.	6·4	7·48	9·30	78·00	3·60	48·09	37·5
Nilgiri Hills (3,000 ft. above sea-level) (1).	53p	0 in.—1 ft. 8 -in.	6·8	18·92	19·58	96·62	14·91	78·8	76·1
	54p	1 ft. 8 in.—3 ft.	6·4	7·98	13·04	61·19	5·18	70·4	44·5
	55p	Below 54p	6·4	8·72	14·03	62·13	5·90	67·6	42·0
Nilgiri Hills (5,000 ft. above sea level) (2).	56p	0 in.—1 ft.	5·5	5·66	10·64	53·15	2·86	50·6	26·9
	57p	1 ft.—2 ft.	5·4	1·94	9·49	20·41	0·28	17·8	3·9
	58p	2 ft. 6 in.—6 ft.	5·4	1·72	13·90	12·37	...	...	...
Nilgiri Hills (7,000 ft. above sea-level) (3).	59p	0 in.—1 ft.	5·2	5·03	12·64	39·79	2·44	48·60	19·3
	60p	1 ft.—3 ft.	5·2	2·73	3·21	85·04	0·31	11·32	9·7
	61p	3 ft.—4 ft. 6 in.	5·6	1·61	3·31	48·64	0·39	24·20	11·8
	62p	4ft. 6 in.— 6 ft.	5·7	2·58	5·21	49·52	0·34	13·20	6·5

The ratio of exchangeable calcium to the total exchangeable bases expressed as percentage ($\frac{z}{x}\times$ 100), in general, decreases down the profile. The figures are often quite low, showing that in such cases exchangeable bases other than calcium predominate, e.g. Dacca, Suri and Nilgiri Hills (2 and 3). The sample 10p seems to be extraordinarily rich in calcium*, perhaps it contains gypsum.

*Duplicate determinations of exchangeable calcium were, however, fairly concordant.

The values of $\frac{z}{y}$ are important in this sense that they give an idea of the comparative lime-status of the soil. The following profiles show a decrease of $\frac{z}{y}$ values down the profile : Dacca, Raipur, Nilgiri Hills (1 and 2).

The profile from Suri shows a maximum value at intermediate depth, whilst profiles from Bidar and Himayatsagar show a minimum value of $\frac{z}{y}$ at an intermediate depth. From the point of view of soil genetics it would appear that the profiles which show an increasing lime-status at greater depths have been produced under comparatively more waterlogged or less free drainage conditions. In agreement with this postulation it will be noticed that the prevailing lime-status of the three profiles from the Nilgiri Hills which were taken at altitudes 3,000 ft. (1), 5,000 ft. (2) and 7,000 ft. (3) are approximately in the order (1) $>$ (2) $>$ (3).

Mattson and Wiklander [1937] have defined two amphoteric points of a soil colloid thus :

(*a*) The equi-ionic point of a soil is defined as that *p*H of a solution which is unaffected by the addition of the soil in its completely unsaturated, free-acid-base ampholytoid condition. In other words, it is that *p*H of the soil at which the absolute capacities to bind acid (y) and base (x) are equal, i.e. at which the net capacity to bind acid or base is equal to zero, i.e. $x—y=0$.

(*b*) The point of exchange neutrality is defined as that *p*H of a soil suspension which is unaffected by the addition of a neutral salt. It is that *p*H at which the increments produced by the salt in the capacities of the soil to combine with the anions and cations of the solution are equal, or where $(x_1—x)—(y_1—y) = 0$, where x and y represent the capacities to bind base and acid respectively in water and x_1 and y_1 the corresponding capacities in a salt solution.

In the application of the ideas of Mattson in the present instance there is one point to be considered. Although the adsorbable cation is the same throughout, namely calcium, the adsorbable anions vary. Assuming that the adsorbability of the anions is the same, it follows that the point of intersection of the buffer curves of electrodialysed soils with the line of zero adsorption should correspond to the equi-ionic point of the soil. Also from general considerations it is evident that the *p*H at which the buffer curves intersect the line of zero uptake of base should be, from theoretical considerations, the same as the *p*H of the soil. Table IV records the *p*H of the samples as obtained by Kuhn's barium sulphate method and the *p*H at which the buffer curves intersect the line of zero uptake of base.

It will be noticed from the table that generally the *p*H indicated by the intersection of the buffer curve with the line of zero adsorption is lower than that obtained by Kuhn's method. This is probably due to the exchange acidity developed by the contact of the soil with the electrolytes present in the buffer solution. In several instances, however, the agreement between the *p*H values obtained by the two methods is quite satisfactory (cp. 7p, 11p, 12p, 18p, 26p, 27p, 33p, 34p, 42p, 46p, 49p, 51p, 53p, 54p, 55p, 56p, 58p, 63p, 68p, 73p, 74p). In a few cases the *p*H obtained from the intersection of the buffer

curve with the line of zero adsorption is higher than that obtained from Kuhn's method, e.g. 45p, 61p, 62p, 64p and 67p.

TABLE IV

Lab. No.	pH by Kuhn's method	pH from the intersection of the buffer curves with the line of zero adsorption	Lab. No.	pH by Kuhn's method.	pH from the intersection of the buffer curves with the line of zero adsorption
1p	5·2	3·9	45p	5·8	6·2
2p	5·3	3·6	46p	6·3	6·6
3p	5·2	3·7	47p	6·1	..
4p	5·4	3·6	48p	5·3	4·6
5p	5·4	4·1	49p	5·4	5·6
6p	6·2	5·2	50p	6·4	5·6
7p	7·8	8·0	51p	7·2	7·1
8p	6·6	5·5	53p	6·8	6·9
10p	6·2	5·7	54p	6·4	6·2
11p	6·2	5·9	55p	6·4	6·2
12p	6·4	6·2	56p	5·5	5·2
14p	6·4	..	57p	5·4	4·8
18p	6·4	6·5	58p	5·4	5·7
19p	6·4	6·0	59p	5·2	3·9
20p	7·3	6·5	60p	5·2	5·6
23p	6·3	5·9	61p	5·6	6·4
24p	6·4	5·7	62p	5·7	6·2
25p	7·1	5·6	63p	5·8	5·9
26p	6·7	6·5	64p	5·9	6·4
27p	6·8	6·5	65p	6·4	..
33p	5·8	5·7	67p	6·4	7·8
34p	5·8	5·5	68p	7·5	7·3
35p	6·4	6·0	70p	5·6	4·4
42p	6·2	6·5	71p	5·7	4·3
43p	7·2	6·2	73p	6·3	6·6
			74p	6·2	6·5

D. Influence of saturation with lime at pH *7·1 on the maximum water-holding capacities and of percentages of imbibitional water*

Most plants have their optimum pH of growth at about neutral point. It was felt desirable to examine as to how far saturation of soil with lime at pH 7·1 affects the maximum moisture-holding capacities and the percentages of imbibitional water of some Indian red soils as determined by Keen-Rackzkowski box experiment.

E. Saturation of soils with lime at pH *7·1*

In obtaining the soils saturated with calcium at pH 7·1 the buffer method of Schofield [1933] has been used. About 100 gm. of soil were treated in a

wide-mouthed bottle with about 250 c.c. of 0·06 *N* p-nitrophenol solution half-neutralized with lime. The mixture was allowed to settle overnight, and on the following day a measured amount of the clear supernatant liquid was pipetted off and titrated with 0·05 *N* hydrochloric acid. The bulk of the supernatant liquid was then decanted off, fresh stock of buffer solution was added to the soil and the whole process was repeated until there was no change in the titration figure of the supernatant liquid. The soil was filtered off in a Buchner funnel, dried in air, passed through 1-mm. sieve and finally stocked in a wide-mouthed bottle.

F. Keen-Rackzkowski box experiment

The boxes used for the experiments were 5 cm. in internal diameter and 1·5 cm. in internal height. The determinations were made as described by Coutts [1932]. Following the work of Fisher [1924], the measurements with the Keen box were made with xylene as well. Fisher assumed that unlike water, xylene is not imbibed by the colloidal material of the soil. The imbibitional moisture capacity, according to Fisher, thus represents the volume of water retained by unit volume of soil, less the volume of xylene retained by the same soil. In the determination of xylene equivalent, the procedure followed by Russell and Gupta [1934] was used.* The boxes were overfilled with air-dry soil. They were then put at 110°C. in an electric oven for 18 hours, allowed to cool in a desiccator, gently repacked and the surplus soil scraped off with a knife. The boxes were weighed and put in xylene to a depth just covering the bottom of the box, in a circular glass trough as in the case of water. The soil was kept in contact with xylene for a period of 18 hours and the final weights of the boxes were noted.

Table VII shows that in general the maximum water-holding capacities and the maximum xylol-holding capacities of these red soils increase on saturating the soil with lime. It may be stated here that, in agreement with the observations given in the following tables, Singh and Nijawan [1936] have shown that the rate of percolation and water-holding capacity of soils containing increasing amounts of exchangeable calcium is invariably followed by an increase in the rate of percolation and water-holding capacity of the soil.

The observations made in field experiments that treatment with lime generally increases the productivity of the land, considered in conjunction with our laboratory data, thus suggest that in cases where the maximum water-holding capacity is increased on saturating the soil with lime, the application of lime in the land should show a response in the increased yield of crops. In the cases where it decreases on saturation with lime, the application of lime by farmers should not show appreciable response in the yield of crops. Pot experiments to test this hypothesis are in contemplation. It is not possible to say anything about the change suffered by the percentages of imbibed water on saturation with lime. In the case of a considerable number of soils the percentage of imbibed water decreases, whilst, in the case of an almost equal number of soils, it increases on saturation with lime.

*The wettings were done in air since it was observed that within the limits of experimental error there was very little difference between the maximum amounts of a liquid held by a soil when wetted in vacuum and in air.

TABLE V

Original soil

(*Results expressed on oven-dry basis*)

Locality	Lab. No.	Maximum water-holding capacity	Maximum xylol-holding capacity*	Vol. of imbibed water per 100 gm. soil
Dacca Farm, Bengal	1p	47·9	40·3	2·7
	2p	50·9	39·1	6·5
	3p	50·0	38·8	6·5
Suri, Birbhum, Bengal	4p	27·7	14·2	11·8
	5p	38·3	31·4	3·0
	7p	47·6	40·1	2·6
	8p	36·4	30·3	2·4
Bidar, Hyderabad	10p	42·5	37·2	0·7
	11p	50·3	43·0	2·1
Himayatsagar, Hyderabad	18p	33·3	28·3	1·6
	19p	50·5	36·3	9·3
	20p	39·9	29·1	7·2
Telankeri, Nagpur (C. P.)	23p	52·4	34·1	14·2
	24p	67·3	42·1	20·0
Telankeri, Nagpur (C. P.)	26p	73·4	44·6	23·3
	27p	53·1	35·8	12·9
Raipur (C. P.)	33p*	37·2	27·9	5·9
Alisagar, Hyderabad	42p**	31·3	22·7	5·8
Kokat, Cannanore, Malabar	45p**	45·3	32·9	8·3
Nilgiri Hills, Madras (3,000 ft.)	53p	48·7	34·8	9·6
	54p	52·1	33·9	14·0
	55p	42·4	33·5	4·8

*Xylol used (E. Merck) was dehydrated with anhydrous calcium chloride.

**Experiments could not be carried out on profile basis as some soil samples were exhausted.

TABLE VI

Soil saturated with lime at pH 7·1

(Results expressed on oven-dry basis)

Locality	Lab. No.	Maximum water-holding capacity	Maximum xylol-holding capacity *	Vol. of imbibed water per 100 gm. soil
Dacca Farm, Bengal . .	1p	49·7	36·7	8·5
	2p	52·2	40·5	6·7
	3p	50·4	38·3	7·3
Suri, Birbhum, Bengal .	4p	30·8	23·9	3·9
	5p	39·8	28·9	7·3
	7p	57·2	..	..
	8p	37·8	33·0	0·8
Bidar, Hyderabad . .	10p	45·8	39·9	1·0
	11p	56·5	44·2	6·9
Himayatsagar, Hyderabad .	18p	36·8	24·4	9·4
	19p	49·2	35·0	10·0
	20p	44·3	29·3	11·4
Telankeri, Nagpur (C. P.) .	23p	62·5	40·3	17·3
	24p	67·3	42·2	20·0
Telankeri, Nagpur (C. P.) .	26p	70·0	54·0	9·4
	27p	51·3	42·0	4·2
Raipur, Central Provinces .	33p**	37·5	..	..
Alisagar, Hyderabad . .	42p**	32·8	26·1	3·5
Kakat, Cannanore, Malabar .	45p**	41·4	34·8	2·4
Nilgiri Hills, Madras (3,000 ft.)	53p	49·8	33·8	11·9
	54p	49·5	39·5	5·2
	55p	47·2	36·7	6·0

*Xylol used (E. Merck) was dehydrated with anhydrous calcium chloride.

**Experiments could not be carried out on profile basis as some soil samples were exhausted.

TABLE VII

Differences of the data in Tables V and VI

(Saturated soil—original soil)

Locality	Lab. No.	Maximum water-holding capacity	Maximum xylol-holding capacity	Vol. of imbibed water per 100 gm. soil
Dacca Farm, Bengal	1p	1·8	—3·6	5·8
	2p	1·3	1·4	0·2
	3p	0·4	—0·5	0·8
Suri, Birbhum, Bengal	4p	3·1	9·7	—7·9
	5p	1·5	—2·5	4·3
	7p	9·6	9·9	—2·6
	8p	1·4	—4·2	—1·6
Bidar, Hyderabad	10p	3·3	2·7	0·3
	11p	6·2	1·2	4·8
Himayatsagar, Hyderabad	18p	3·5	—3·9	7·8
	19p	1·3	1·8	0·7
	20p	4·4	0·2	4·2
Telankeri, Nagpur (C. P.)	23p	10·1	6·2	3·1
	24p	0·0	0·1	0·0
Telankeri, Nagpur (C. P.)	26p	—3·4	9·4	—13·9
	27p	—1·8	6·2	—8·7
Raipur, Central Provinces	33p	0·3	5·1	..
Alisagar, Hyderabad	42p	1·5	3·4	—2·3
Kakat, Cannanore, Malabar	45p	—3·9	1·8	—5·9
	53p	1·1	—1·0	2·3
Nilgiri Hills, Malabar (3,000 ft.)	54p	2·6	—0·1	—8·8
	55p	4·8	4·2	1·2

SUMMARY

1. Buffer curves were obtained in the case of a number of soils representing several typical red soil profiles from Dacca (Bengal), Suri (Bengal), Bidar (Hyderabad), Himayatsagar (Hyderabad), Chandkhuri Farm (Raipur, C. P.), Nilgiri Hills (Madras, 3,000 ft. 5,000 ft., and 7,000 ft. above sea-level). Data for some typical base-exchange properties were also obtained, e.g. maximum saturation capacity, percentage base saturation and percentage of exchangeable calcium.

2. Almost all the buffer curves indicate a more or less definite inflexion at pH 9·8 and frequently a second inflexion either at pH 2·9 or at pH 4·6. The buffer values $\frac{\Delta B}{\Delta pH}$ of the soils at pH's 2·9, 4·6 and 9·8 were calculated from the curves and within certain limits of variations (approximately 10 per cent) it is possible to classify the profiles into the following four groups :

(*a*) Increase of $\frac{\Delta B}{\Delta pH}$ down the profile : Dacca, Suri and Raipur.

(*b*) Decrease of $\frac{\Delta B}{\Delta pH}$ down the profile : Bidar, Nilgiri Hills (3,000 ft. and 7,000 ft. above sea-level).

(*c*) Maximum value of $\frac{\Delta B}{\Delta pH}$ at intermediate layer : Himayatsagar.

(*d*) $\frac{\Delta B}{\Delta pH}$ fairly constant down the profile : Nilgiri Hills (5,000 ft. above sea-level).

3. The percentage base-saturation, in general, decreases down the following profiles : Dacca and Nilgiri Hills (5,000 ft. above sea-level). It shows a tendency to increase with the profile from Bidar. In the case of the profile from Suri and Nilgiri Hills (7,000 ft. above sea-level) the percentage base-saturation shows a maximum value at intermediate layers. The Himayatsagar, Raipur and Nilgiri Hills (3,000 ft. above sea-level) profiles on the other hand show a minimum percentage base-saturation at an intermediate layer.

4. In general the ratio of exchangeable calcium as percentage of total exchangeable bases decreases down the profile. These ratios are often quite low, showing that in such cases exchangeable bases other than calcium predominate.

5. The ratio of exchangeable calcium to the total saturation capacity shows a decrease down the following profiles : Dacca, Raipur, Nilgiri Hills (3,000 ft. and 5,000 ft. above sea-level). The profiles from Suri show a maximum value at intermediate depth, whilst profiles from Bidar and Himayatsagar show a minimum value of the ratio at intermediate depth of the profile.

6. A number of red soils of India collected on profile basis were treated with half-neutralized p-nitrophenol calcium buffer of pH 7·1 until the soils were saturated with lime. The soils were subsequently freed from adhering salts. The following properties of these soils before and after treatment with lime-buffer were compared :

(*a*) Maximum water-holding capacity.

(*b*) Maximum xylene-holding capacity.

(*c*) Percentage imbibitional water.

It is found that in general the maximum water-holding and the maximum xylene-holding capacities increase on saturation with lime. The percentage of imbibitional moisture-holding capacity, however, does not show such general behaviour.

ACKNOWLEDGEMENTS

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FORMATION OF OIL IN SOME OLEIFEROUS *BRASSICAE*

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Of the oilseed crops commonly grown in Northern India, *toria* (*Brassica napus* L. var. *dichotoma* Prain) and *sarson* (*Brassica campestris* L. var. *sarson* Prain) occupy an important position as regards acreage in the Punjab. A review of the literature available on these two crops shows that practically no work has so far been done on the course of formation of oil in the developing seeds in order to ascertain the period of most rapid oil formation and thus to coordinate the results obtained from such a study with the effect of various factors governing the yield and quality of the oil. In order to obtain some evidence on this point, the Oilseed Section, Lyallpur, has during the past three years made a few preliminary investigations which form the subject matter of this note. A brief reference to the results obtained in 1936-37 was made in the progress report, submitted to the Imperial Council of Agricultural Research, on the scheme for additional research on oilseeds in the Punjab for that year. The observations were then made on the crops grown with two irrigations and without the application of any manure. The experiments were repeated on both *toria* and brown *sarson* during the two subsequent seasons (1937-38 and 1938-39), and in order to widen the scope of these investigations the following manurial and irrigation treatments were included in the trials :—

(*i*) No manure and no irrigation

(*ii*) No manure but one irrigation applied at the commencement of critical stage of oil formation (*vide* results obtained in the year 1936-37)

(*iii*) No manure and two irrigations, i.e. one at the commencement of critical stage of oil formation and second during the maximum fruiting period

(*iv*) Farmyard manure equivalent to 25 lb. of nitrogen per acre applied before sowing and two irrigations as above

(*v*) *Toria* cake equivalent to 25 lb. of nitrogen per acre applied before sowing and two irrigations as above

(*vi*) Sodium nitrate equivalent to 25 lb. of nitrogen per acre applied at the commencement of critical stage of oil formation and two irrigations as above

The investigations being of a preliminary nature, the experiment was kept very simple in form. The various treatments were given to the crops grown on small plots of 1/180 acre each. It may be pointed out that as compared to the years 1936-37 and 1938-39, the year 1937-38 was characterized by the prevalence of comparatively low temperatures during the main blooming periods of the crops, i.e. between November and February, and for this reason the results obtained during this year are somewhat different from those obtained during the other two years. This variation in the general run of temperatures was propitious from the point of view of these studies as it gave an opportunity for gauging the effect of variable weather on the rate of oil formation. The results obtained during the aforesaid three years are of great interest and, since they are likely to prove very useful in further research on these crops, they are presented here in the form of a short note.

Briefly put, the procedure adopted was as follows :—

Freshly opened flowers in sufficiently large numbers were tagged during each of the three different bloom periods which were taken to be as follows :—

Crop	Early bloom period	Mid bloom period	Late bloom period
Toria	First week of November	Last week of November	Middle of December
Brown *sarson*	Last week of December	Middle of January	First week of February

Samples of the developing ovules of known ages were obtained in all cases for the determination of moisture and oil content at regular intervals of ten days throughout the growing season. Measurements of length and breadth of 25 ovules were recorded in the case of each sample. The fresh and dry weights of 1,000 ovules were also determined in each case. The results obtained during these investigations are summarized in Tables I-III from which the following general conclusions can be drawn :—

(*a*) In all the years the maximum size of the developing ovules as determined by the greatest length and breadth was attained in about 40 and 50 days from the date of opening of flowers in *toria* and brown *sarson* respectively (Table I). Taking the average of all treatments in *toria* in the years 1937-38 and 1938-39 the length and breadth of ovules when 40 days old were 2·20 mm. and 1·92 mm. respectively, and in brown *sarson* the corresponding figures in the case of 50 days old ovules were 2·23 mm. and 1·99 mm.

(*b*) The fresh weight of developing ovules in both *toria* and brown *sarson* continued to increase at a rapid rate till about a month after fertilization, at the end of which time it turned the scale at a figure seven times the weight recorded in the case of ten days old ovules in *toria* and about 17 times in the case of brown *sarson*. Thereafter the weight remained more or less constant in *toria*, whereas in brown *sarson* there was a slight increase till the ovules were 60 days old. At full maturity, however, there was a decrease of about 33 per cent in the maximum fresh weight in brown *sarson*, which may possibly

be due to the desiccating effect of somewhat hot weather prevailing during March when brown *sarson* reaches maturity. The dry weight increased as the seed developed, obviously due to storage of greater quantities of food materials with an advance in development (Table I).

(*c*) Except for the first few days of seed (fertilized ovule) development the percentage of moisture decreased as the seed advanced in age. For example, in *toria* the moisture content in the case of all determinations made in all the years under consideration averaged 75·05 per cent when the ovules were ten days old. The average moisture percentage in the case of 20 days old ovules had increased to 80·73 and thereafter with an advance in the age of ovules it continued to decrease steadily till it reached the figure of 36·14 in the case of 70 days old ovules. Similarly, in brown *sarson* the average moisture percentage when the ovules were ten days old was 65·73, and in the 20 days old ovules it was 79·27 as against 12·77 when the ovules were 70 days old. Here a difference in the moisture content of 70 days old ovules of *toria* and brown *sarson* is noticeable which is presumably due to weather, which is mild and cold in the case of *toria* and somewhat warm in the case of *sarson* at the time when the ovules attain an age of 70 days in these two crops.

(*d*) The percentage of oil increased as the seed developed. For example, in the year 1936-37 the most rapid formation of oil in developing seed, expressed as the percentage of ether extract on dry basis, began when the seed was about 20 days old, and continued for another 20 days in the early and mid bloom periods in *toria* (Table II). The maximum percentage of oil was nearly reached at the age of 40 days, there being slight increase after that age till maturity. Similar conclusions were arrived at in the case of brown-seeded *sarson* in the mid and late bloom periods also. For instance, in brown *sarson* the oil percentage (average of mid and late bloom periods) in 40 days old seeds had increased to 44·88 from 4·56 found in the 20 days old seeds. Similarly in *toria* the oil percentage (average of early and mid bloom periods) in 40 days old seeds was 41·64 as against 5·71 obtained in the case of 20 days old seeds.

(*e*) In the case of early-formed ovules in brown-seeded *sarson* and late-formed ovules in *toria*, in all the three seasons, the increase in the oil content was very slow and the amount of oil formed was also much less (Table II). This fact could be attributed to the adverse effect of frost and cold which synchronized with the early bloom period in brown-seeded *sarson* and late bloom period in *toria*. For example, the oil percentage in the late bloom period (average of three years), when the seed was 40 days old, was 16·26 only in *toria*, as compared to 41·28 and 39·59 in early and mid bloom periods, respectively. In brown *sarson* the oil content in the case of ovules formed in early bloom period, when 40 days old, was 22·52 per cent, as compared to 37·40 and 41·07 formed in the mid and late bloom periods, respectively.

(*f*) Further confirmation of the effect of weather on the rate of oil formation was obtained in the year 1937-38 when, owing to the severity of cold during the mid bloom periods of both *toria* and brown-seeded *sarson*, the accumulation of oil in the case of all treatments was rather slow. The period of most rapid oil formation in the ovules during this year varied from about 30 to 60 days in *toria* and from about 30 to 50 days in brown-seeded *sarson* (Table III), as compared to about 20 to 40 days after flowering during the year 1936-37

(a year of normal temperatures). Taking the average for all treatments in 1937-38, the oil percentage, when the ovules were 40 days old, was only 19·64 and 27·38 in *toria* and brown *sarson* respectively, and reached the normal figure, viz. 42·57 and 44·38 when the ovules were 60 and 50 days old in *toria* and brown *sarson*, respectively. On the other hand, in 1938-39, when the temperatures were midway between those in the other two years under consideration, the rate of oil formation was greater than in 1937-38, the oil percentage (average of all treatments) in the former year when ovules were 40 days old being 36·79 and 38·94 in *toria* and brown *sarson*, respectively (Table III). In 1938-39 the fresh and dry weights of 1,000 ovules were also comparatively greater in all cases as compared to 1937-38. This is attributed to better development of ovules resulting from more suitable climatic conditions which prevailed during 1938-39. It is, therefore, concluded that under the conditions of these experiments the rate of oil formation in the two crops under consideration is mainly controlled by the meteorological conditions obtaining during the periods of seed development.

(*g*) The effect of manurial and irrigation treatments on the fresh and dry weights of 1,000 ovules and on the rate of oil formation was negligible.

Further work by the junior author, who is mainly responsible for the chemical investigations relating to this scheme, is in progress and it is hoped that with the accumulation of more data further light will be thrown on the various aspects of the problem concerned.

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TABLE I

Relation between size, weight and moisture in developing ovules of toria *and brown* sarson *(average of all treatments) during mid bloom periods of their growth in 1937-38 and 1938-39*

Name of crop	Number of days after flowering	Length (mm.)			Breadth (mm.)			Fresh weight of 1,000 ovules (grams)			Dry weight of 1,000 ovules (grams)			Moisture percentage		
		1937-38	1938-39	Average	1937-38	1938-39	Average	1937-38	1938-39	Average	1937-38	1938-39	Average	1937-38	1938-39	Average
Toria	10	1·34	1·37	1·35	0·92	1·03	0·97	0·5096	0·8491	0·6793	0·1352	0·1948	0·1650	73·36	76·74	75·05
	20	1·90	2·00	1·95	1·59	1·64	1·61	2·3563	3·2188	2·7875	0·4877	0·6005	0·5441	80·15	81·32	80·73
	30	2·15	2·15	2·15	1·88	1·86	1·87	4·1963	4·9334	4·5648	0·8746	1·1693	1·0219	79·18	76·30	77·74
	40	2·22	2·19	2·20	1·96	1·89	1·92	4·4784	4·8966	4·6875	1·2643	1·8018	1·5330	71·79	63·09	67·44
	50	2·10	2·15	2·12	1·84	1·87	1·85	4·2342	5·2523	4·7432	1·6779	2·5325	2·1052	60·40	51·73	56·06
	60	2·06	2·15	2·10	1·79	1·86	1·82	4·2370	5·3743	4·8056	2·1778	3·1659	2·6718	48·59	41·09	44·84
	70	2·05	2·14	2·09	1·75	1·85	1·80	4·1349	5·2203	4·6776	2·4534	3·5074	2·9804	39·80	32·49	36·14
	80	...	2·04	...	...	1·78	...	...	4·7194	...	...	3·6119	...	...	23·62	...
Brown *sarson*	10	1·09	1·06	1·07	0·74	0·74	0·74	0·2620	0·3736	0·3173	0·1086	0·0945	0·1015	56·73	74·73	65·73
	20	1·87	1·85	1·86	1·50	1·47	1·48	1·7649	2·4564	2·1106	0·3933	0·4567	0·4250	77·47	81·08	79·27
	30	2·17	2·10	2·13	1·92	1·86	1·89	5·5154	5·6631	5·5892	1·0488	1·2846	1·1667	81·38	78·17	79·77
	40	2·20	2·18	2·19	1·98	1·90	1·94	6·2489	6·7205	6·4847	1·7532	2·3533	2·0532	71·88	64·79	68·33
	50	2·22	2·24	2·23	2·00	1·99	1·99	7·2854	7·0977	7·1915	3·3206	3·4435	3·3820	54·37	51·48	52·92
	60	2·23	2·20	2·21	1·98	1·98	1·98	7·1604	7·8480	7·5042	4·2752	4·7689	4·5220	40·15	39·18	39·66
	70	2·14	2·06	2·10	1·93	1·85	1·89	4·7005	5·5018	5·1011	4·3008	4·5150	4·4079	8·48	17·07	12·77

TABLE II

Oil percentage in developing ovules of toria *and* brown sarson *during different periods of their growth in 1936-37, 1937-38 and 1938-39*

(No manure and two irrigations)

Name of crop	Number of days after flowering	Oil percentage on dry basis								
		Early bloom period			Mid bloom period			Late bloom period		
		1936-37	1937-38	1938-39	1936-37	1937-38	1938-39	1936-37	1937-38	1938-39
Toria	10	2·14	2·68	1·56	1·87	1·86	1·38	1·54	1·43	0·93
	20	6·26	7·62	8·69	5·17	2·90	4·22	5·10	1·47	1·83
	30	34·90	31·98	23·90	27·44	9·25	22·94	5·27	4·47	7·76
	40	40·29	38·62	44·94	43·00	32·92	42·84	13·16	7·48	28·13
	50	43·18	46·03	45·54	45·52	41·27	44·25	..	32·35	44·42
	60	43·83	44·01	46·38	46·30	43·06	47·31	..	45·51	45·72
	70	44·44	43·08	40·79	45·02	41·52	44·20	..	..	..
	80	45·94	43·13	44·32	..	..	..	..	..	..
Brown sarson	10	3·23	0·41	0·97	3·38	0·95	0·71	2·09	0·72	1·62
	20	3·80	1·32	1·62	4·86	1·66	1·64	4·27	2·28	4·28
	30	4·09	1·74	2·79	28·88	4·67	11·26	35·70	14·53	16·73
	40	27·24	12·19	28·12	43·88	31·19	37·12	45·89	36·18	41·13
	50	35·30	36·00	42·30	48·81	46·04	46·03	43·78	43·10	43·27
	60	50·40	47·13	41·55	..	46·59	43·21	..	..	41·54
	70	50·48	48·19	45·97	..	47·70	49·57	..	..	..
	80	49·70	51·12	45·48	..	..	44·11	..	..	..
	90	..	51·47	..	..	..	..	..	..	..

(..) No samples were available owing to the crop being over.

TABLE III

Oil percentage in developing ovules of toria *and* brown sarson *during mid bloom periods of their growth in 1937-38 and 1938-39 in different irrigation and manurial treatments*

Name of crop	Number of days after flowering	Oil percentage on dry basis in 1937-38						Oil percentage on dry basis in 1938-39					
		No manure and no irrigation	No manure but one irrigation	No manure and two irrigations	Farmyard manure and two irrigations	*Toria* cake and two irrigations	Sodium nitrate and two irrigations	No manure and no irrigation	No manure but one irrigation	No manure and two irrigations	Farmyard manure and two irrigations	*Toria* cake and two irrigations	Sodium nitrate and two irrigations
Toria	10	1·30	1·10	1·17	1·58	0·90	1·71	1·06	0·94	1·36	1·09	1·68	1·25
	20	1·35	1·80	1·60	2·66	1·49	2·36	3·45	3·94	3·23	3·42	3·43	3·14
	30	3·25	3·66	5·10	9·11	3·57	9·77	18·29	17·52	15·57	15·69	14·10	17·41
	40	17·72	14·10	18·32	24·30	13·78	29·63	36·42	38·16	37·07	37·30	36·90	34·92
	50	38·80	32·73	36·15	38·54	32·97	39·21	42·29	43·23	43·73	40·02	41·96	40·37
	60	44·49	40·99	42·92	42·54	40·67	43·80	41·84	45·29	43·62	42·65	41·45	45·09
	70	44·55	40·61	43·69	41·54	42·52	44·47	42·45	44·37	44·84	41·08	45·78	41·00
	80	...	...	...	...	...	...	43·86	43·01	42·74	41·55	41·43	43·68
Brown *sarson*	10	0·43	0·57	0·71	0·45	0·48	0·39	1·17	0·84	1·01	1·13	0·96	1·31
	20	1·13	1·23	1·75	1·29	1·29	1·39	1·94	1·47	1·72	3·05	1·67	3·27
	30	8·29	5·11	3·16	4·83	3·92	3·88	15·30	15·68	14·33	15·62	11·75	12·99
	40	29·52	28·56	26·76	27·97	26·64	24·82	41·07	36·05	40·26	38·33	36·43	41·51
	50	47·00	44·62	43·05	44·07	44·33	43·20	47·04	43·82	46·40	47·35	45·93	42·01
	60	45·50	47·72	45·88	45·74	48·39	45·69	47·20	50·26	48·25	49·50	47·99	47·98
	70	45·61	48·68	48·94	43·81	49·22	46·37	44·92	46·04	47·67	47·34	46·65	44·24

A NEW *CORTICIUM* ON ORANGE STEM

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(Received for publication on 7 August 1939)

(With Plate I)

IN July 1938, when the writer was touring in Burhanpur (Nimar district), Central Provinces, a few orange trees (*Citrus aurantium*), about four years old, in an orchard were observed to have a white mycelial growth on the lower part of the stem facing south-west. From a distance it looked as if the stem was washed with lime. The growth was uniformly white and compact; at the margins the hyphæ spread out like a fan and were feathery in appearance. Though this white growth covered about 10 cm. of the circumference of the stem up to a height of about 30 cm. from the ground level, still the stem looked in no way unhealthy; there was no exudation of gum, no depression or drying or rotting of the bark; on scraping the bark below the white felt of mycelium the plant tissues were observed to be normal. The crown roots were also healthy and free from this mycelial growth.

Morphology

When the material collected at Burhanpur was examined in the laboratory at Nagpur the fungus mycelium was found to belong to a Basidiomycete, judging from the presence of club-shaped basidia bearing sterigmata.

In hand sections and in microtomic sections the mycelium was found to be wholly superficial; but the hyphæ filled the clefts or crevices formed by the cracking and scaling of the bark. In hand sections it was not always possible to get the film of the mycelium attached to its substratum, as the section of the film readily separated from the section of the bark. In microtomic sections the paraffin ribbon with the sections was often badly torn as in the mycelium were embedded minute particles of stone and dirt. At times along with this Basidiomycete were found hyphæ and pycnidia of a Diplodia, which was growing within the tissues of the bark; the basidiomycetous hyphæ often overran the pycnidia and the particles of stone and dirt, and completely covered them.

The mycelium can be roughly divided into three layers. The layer in contact with the substratum is thin and consists of long, delicate strands of hyphæ, running along the stem and parallel to each other; they are slender and of rather uniform diameter, about 3μ; they are sparingly septate and very little branched; they are compact but not twisted; they are without clamp connexions or anchor cells (Plate I, figs. 1 and 2); hyphal fusions have been observed, but very rarely. From some of these long hyphæ arises a broad

reticulum layer. It consists of profusely branched hyphæ with short, broad cells forming a loose network (Plate I, fig. 2) ; these cells are of varying shapes, such as globular, globoid, geniculated, cylindrical, etc. ; they are $5 \cdot 0$-$7 \cdot 5\ \mu$ wide ; the length is more variable, $8 \cdot 3$-$21 \cdot 6\ \mu$; two neighbouring cells often fuse together. From this broad reticulum layer arises tangentially a row of cylindrical, erect and hyaline cells, the basal cells, $10 \cdot 0$-$16 \cdot 6 \times 3 \cdot 3$-$6 \cdot 6\ \mu$; on these basal cells are borne the basidia. Neither hyphal clumps nor gloeocystidia are present. The hyphæ are thin-walled and not incrusted.

Basidia and basidiospores

Basidia do not arise directly from the reticulum layer of cells ; but they are developed from basal cells which grow laterally from the reticulate cells. The basal cell develops usually one basidium terminally (Plate I, figs. 3, 4, 7 and 10), but at times basidia may also be produced laterally (Plate I, figs. 6, 8, 9 and 12). The basidium is thin walled, hyaline and club shaped with a globular head ; it measures $13 \cdot 3$-$25 \cdot 0\ \mu$ in length ; the head is $6 \cdot 6$-$10 \cdot 0\ \mu$ in width where it is broadest ; at the base the basidium measures $3 \cdot 3$-$6 \cdot 6\ \mu$. From the basidium are developed four sterigmata ; they are pointed at the apex and broad at the base ; they are usually short, but at times they may be elongated ; they are then very narrow in width. They are $2 \cdot 5$-$6 \cdot 6\ \mu$ in length and $0 \cdot 83$-$2 \cdot 5\ \mu$ in width at the base.

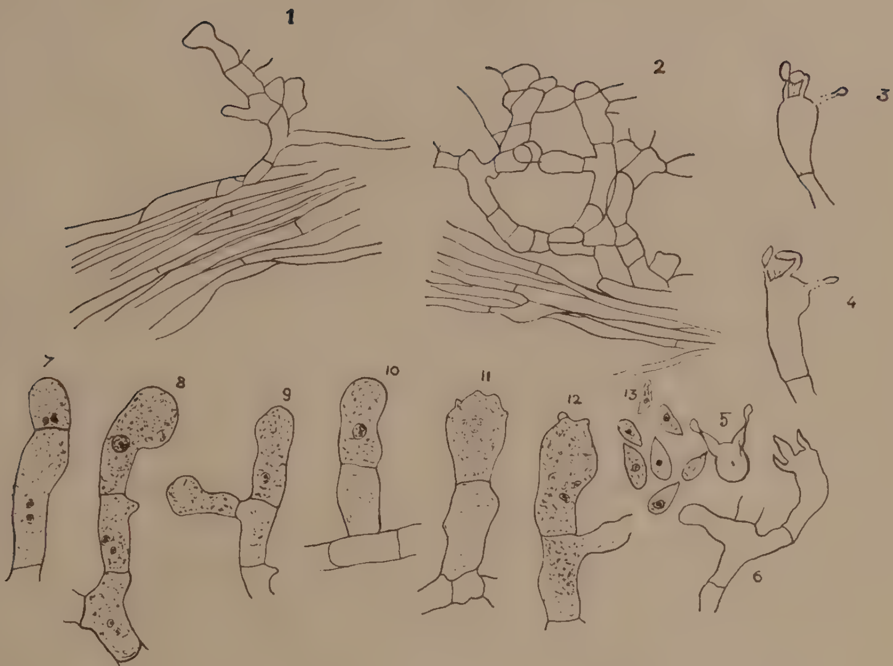
The basidia stain very deeply so also the basidiospores but the sterigmata stain very faintly. The basidiospores are oval in shape, pointed at the base and rounded at the apex (Plate I, fig. 13) ; one side is occasionally slightly flattened. They measure $6 \cdot 0$-$13 \cdot 8 \times 2 \cdot 5$-$7 \cdot 0\ \mu$, generally $8 \cdot 3$-$10 \cdot 3 \times 3 \cdot 3$-$5 \cdot 0\ \mu$.

Detailed observations on the cytology of the fungus have not been carried out because of the fresh material not being available in sufficient quantity.

The long hyphæ attached to the substratum have uninuclear cells ; the cells forming the broad reticulum layer are binuclear ; the nuclei are in pairs ; at times two pairs of nuclei have been observed in some of these small, broad cells ; the basal cells arising laterally from this reticulum layer are also binuclear (Plate I, figs. 7, 8 and 12) ; the very young basidium, the one which is being formed from the basal cells is also binuclear (Plate I, fig. 7) ; at a later stage the basidium which has still not developed the sterigmata is uninuclear the nucleus being larger than the nuclei in the basal cells and in the cells of the reticulum layer (Plate I, figs. 8, 9 and 10). As the basidium begins to form small protuberences on its head, which are the beginnings of the sterigmata, the single nucleus divides and forms four small nuclei (Plate I, figs. 11 and 12). In the basidium which had developed mature spores the cell contents are vacuolated ; the nucleus has not been seen in such a basidium. The basidiospores are uninucleate (Plate I, fig. 13).

Taxonomy

According to the classification of Clements and Shear [1931] the fungus under study is a *Corticium*, as cystidia are lacking, spores are hyaline, pileus consists of one layer and is resupinate.



1, 2. Mycelium of fungus drawn from a transverse section of a citrus bark (×450) ; *3, 4.* Terminal basidia with sterigmata and basidiospores (×450) ; *5.* Head of basidium seen from above (×450) ; *6.* Lateral basidium (×450) ; *7.* Young basidium with its basal cell ; both are binucleate (×675) ; *8.* Basidium with a single fused nucleus borne on a binucleate basal cell arising from a short broad binucleate cell (×675) ; *9.* Terminal and lateral basidia (×675) ; *10.* Terminal basidium with one nucleus formed by the fusion of two nuclei (×675) ; *11, 12.* Basidia with immature sterigmata and four nuclei (×675) ; *13.* Basidiospore (×450)

Two species of *Corticium*, viz. *C. koleroga* (Cke.) v. Hohn and *C. salmonicolor* B. and Br., have been reported to occur on *Citrus*. In India the former has been known to do much damage to coffee, *Coffea arabica*, and is the cause of the well-known 'koleroga' disease of coffee, but has not been so far known to occur on any species of *Citrus*. The other, *C. salmonicolor*, is known throughout the tropics, including India, as the pink disease of *Citrus*, and also attacks many other woody plants.

C. koleroga attacks leaves, twigs and large limbs and fruits of *Citrus* in Florida. This fungus, according to Wolf and Bach [1927], produces brown rhizomorphs which 'can be readily traced from the sporophores backward along the petioles to the twigs and thence to the older wood'. On twigs and wood brown-coloured sclerotia are developed. The basidia arise as terminations of short, lateral branches. They measure $10 \cdot 0$-$12 \cdot 0 \times 7 \cdot 0$-$8 \cdot 0$ μ and have four, rarely six, sterigmata; the basidiospores are hyaline, flattened on the opposed faces, round above and tapered below; they measure $9 \cdot 0$-$13 \cdot 0 \times 3 \cdot 5$-$5 \cdot 0$ μ with $10 \cdot 5 \times 4 \cdot 5$ μ as the most common size. According to Narasimhan [1933] the basidia on the coffee host measure $8 \cdot 5$-$12 \cdot 0$ μ in diameter and the basidiospores $9 \cdot 1 \times 3 \cdot 4$ μ; the length of the sterigmata is inconsistent, varying from $5 \cdot 0$ to $11 \cdot 5$ μ; the basidiospores are slightly flattened on one side, rounded at one end and somewhat pointed at the other.

The pink disease, as the name indicates, forms a salmon pink-coloured fungus growth on the host plant; the basidiospores measure $9 \cdot 0$-$12 \cdot 0 \times 6 \cdot 0$-$8 \cdot 0$ μ.

Both these species of *Corticium* form sclerotia.

The *Corticium* under study is therefore evidently different from the two species known to occur on *Citrus*. The difference lies in the hymenium being white (whereas the hymenium of *C. koleroga* and of *C. salmonicolor* is coloured), in the basidia being much larger, and the basidiospores smaller than those of the other two *Corticiums*, and in the absence of sclerotia.

If the key to the species of *Corticium* given by Burt [1926] is to be followed, then our species would belong to the same group as *C. bombycinum* (Sommerf.) Bresadola, *C. sociatum* Burt and *C. confluens* Fries. The characters of this group are:—Substance not appreciably coloured, gloeocystidia absent, hymenium white or whitish when growing, spores not globose but more elongated, large and more than 6 μ long.

Our species is clearly distinct from these three species.

C. bombycinum is in section 200-1,000 μ thick; the hyphæ are suberect, loosely interwoven and thick walled.

C. sociatum has small fructifications, 2-10 mm. long and 1-3 mm. wide; hyphæ are loosely interwoven near the substratum; a few embedded spores are present.

C. confluens has rather thick and waxy-membranaceous fructifications, 2-8 cm. long and 1-3 cm. wide; the fructifications are composed of ascending densely interwoven and agglutinate hyphæ.

Herbarium specimens and microscope preparations of the *Corticium* on the bark of an orange tree were sent to Dr Fawcett, Professor of Plant Pathology, University of California, for favour of examination and opinion. Dr Fawcett very kindly examined them and sent them to Dr J. N. Couch of the

University of North Carolina as the fungus 'was something with which he was not at all familiar'. Some more microscope preparations were sent to Dr Couch who very kindly took the trouble of examining them and reported,' I have examined the mycelium, basidia and spores and think they considerably resemble *Corticium* .... Several species of *Corticium*, for example *C. koleroga*, *C. stevensii*, and *C. vagum*, have been reported as parasites on the leaves and stems of higher plants.......... Furthermore, your species, though apparently related to the above-mentioned ones, seems to be distinct. I should like to see a piece of the dried specimen, since it is impossible to pass judgment on material preserved in formalin. However from the information I can gather, it seems to me that you would be safe in describing the fungus as a new species of *Corticium*'.

I therefore propose the name *Corticium album* n. sp.

Fructifications up to about 30 cm. long and about 10 cm. wide, smooth, shining, white, thin, resupinate and adnate, margin feathery; in section 70-300 μ thick, composed of hyaline, little branched, thin-walled, sparingly septate parallel hyphæ, about 3 μ in diameter, compact, running longitudinally over the substratum and not twisted, giving rise to a broad layer of thin-walled, loosely interwoven, branching, hyaline hyphæ with broad, short cells; from this reticulum layer arise laterally thin-walled, hyaline, cylindrical, basal cells 10·0-16·6 μ long and 3·3-6·6 μ broad, from the basal cells basidia are developed terminally and also at times laterally hyaline, thin-walled, clavate, 13·3-25·0 μ long and 6·6-10·0 μ wide at the head; sterigmata four, short, hyaline, broad at the base and tapering at the apex, 2·5-5 $\times$ 0·8-2·5 μ; basidiospores hyaline, oval, rounded at the apex, pointed at the base, one side at times flat, 8·3-10·3 $\times$ 3·3-5·0 μ; no gloeocystidia; hyphæ not incrusted. On bark of living stems of *Citrus aurantium*.

My thanks are due to Dr H. S. Fawcett and Dr J. N. Couch for very kindly examining the material sent to them.

Summary

A new species of *Corticium* growing on the trunk of orange trees, *Citrus aurantium*, is described. The fungus forms a white film on the bark from the ground level up to a height of about 30 cm.; the film is about 10 cm. broad. The growth is superficial; it is not known to cause any damage to the tree.

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RESEARCH NOTES

DELAYED GERMINATION IN SESAME, *SESAMUM INDICUM*

BY

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AND

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(Received for publication on 13 September 1939)

(With one text-figure)

IN the course of our investigations on sesame selections, a great variation in the period of seed germination has been frequently observed in this laboratory. The normal period of germination in these isolations does not, as a rule, exceed four to five days, although some of them sprout in less than two days. But the remarkable feature of a particular type observed is its delayed germination. The seeds did not germinate even after putting them on a moist blotting paper for over seven months. They appear quite healthy with very rough, black and constricted seed-coat. When the black coat of such a seed is removed and the embryo is placed on a moist blotting paper in Petri dish, it becomes green, showing thereby its viability and proving that the seed-coat is chiefly responsible for the delayed germination.

The phenomenon of delayed germination has been studied in several groups of plants by various workers. They have established that there can be various causes bringing about this phenomenon, viz. genetical, physiological, morphological or environmental. In this connexion Crocker's recent paper [1938] may be consulted.

In the present case the cause of the delayed germination is the structure of the seed-coat. In the normal seed the coat consists of one or two layers of cells which are more or less rounded and loosely arranged, followed by a non-cellular membraneous layer.

In the case of seeds with delayed germination, on the other hand, the cells are elongated, arranged lengthwise (Fig. 1 L) and packed closely towards one side which makes the seed-coat unusually thick. Within these cells two regions can be distinctly marked, the outer (hyaline region, Fig. 1 D) and the inner (with striations, Fig. 1 E). On the outer surface of the cells, there exists a thick coating of some impervious substance (Fig. 1 A, B), which presumably obstructs the intake of water and oxygen. In the case of the normal seed, the loose arrangement of the cells and the absence of the impervious substance evidently allow the free passage of water and oxygen.

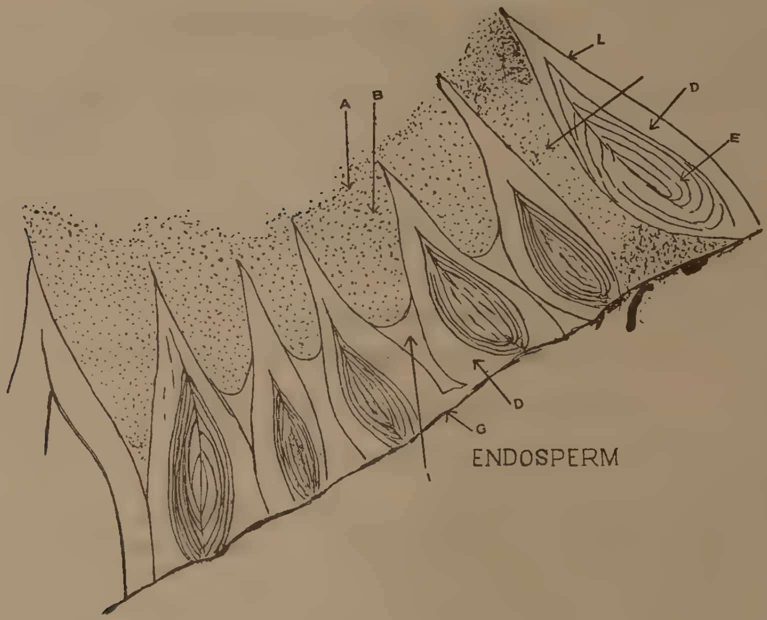

FIG. 1. T. S. of sesame seed showing delayed germination ($\times$ 433)

A = Surface coating on the seed-coat
B = Impervious layer
C = Canal leading from outer surface to the endosperm
D = Hyaline part
E = Striation
G = Non-cellular layer inbetween the coat and the endosperm
I = Inter-cellular space
L = Elongated cell

An interesting feature in the structure of the seed-coat with delayed germination is that at places the impervious substance, referred to above, surrounding the seed-coat, penetrates through the inter-cellular space, thus forming a sort of canal (Fig. 1 C). At other places it stops half-way, as there is not enough continuous space leading to the endosperm (Fig. 1 I). The significance of this structure is not definitely known but presumably it has some connexion with the germination of the seed. When the seed finds a favourable environment, the substance in the canal must be subjected to gradual decay, thus making way for water and oxygen to enter. It may then bring about the germination of the seed, though the time taken may vary in individual cases, ensuring the distribution of this variety of sesamum over a number of seasons. This type of sesamum was commonly found at Dindori (Mandla district of the Central Provinces) in November 1938. Seeds were collected from some stray plants growing on the bunds of the fields at the Government Seed Farm, Dindori, and from the cultivators' fields. Such

plants are not harvested and they are regarded as wild sesamums by the inhabitants. Locally they are known as *baneli tilli* meaning wild sesamum. The seeds obtained are black with rough surface and with constrictions and exhibit delayed germination. Transverse sections also exhibit the seed-coat structures described above.

Such seeds are of no use to the farmer. Their presence in the cultivated area where the sesamums are grown is highly objectionable, as their spontaneous appearance in the pure strains will spoil the purity of the crop. While in the economy of nature these may be serving a useful purpose, they cause a distinct loss to the growers.

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A SPECIES OF *PHYLLACTINIA* OCCURRING ON ALMOND (*PRUNUS AMYGDALUS*)

BY

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(Received for publication on 10 January 1939)

(With Plate II)

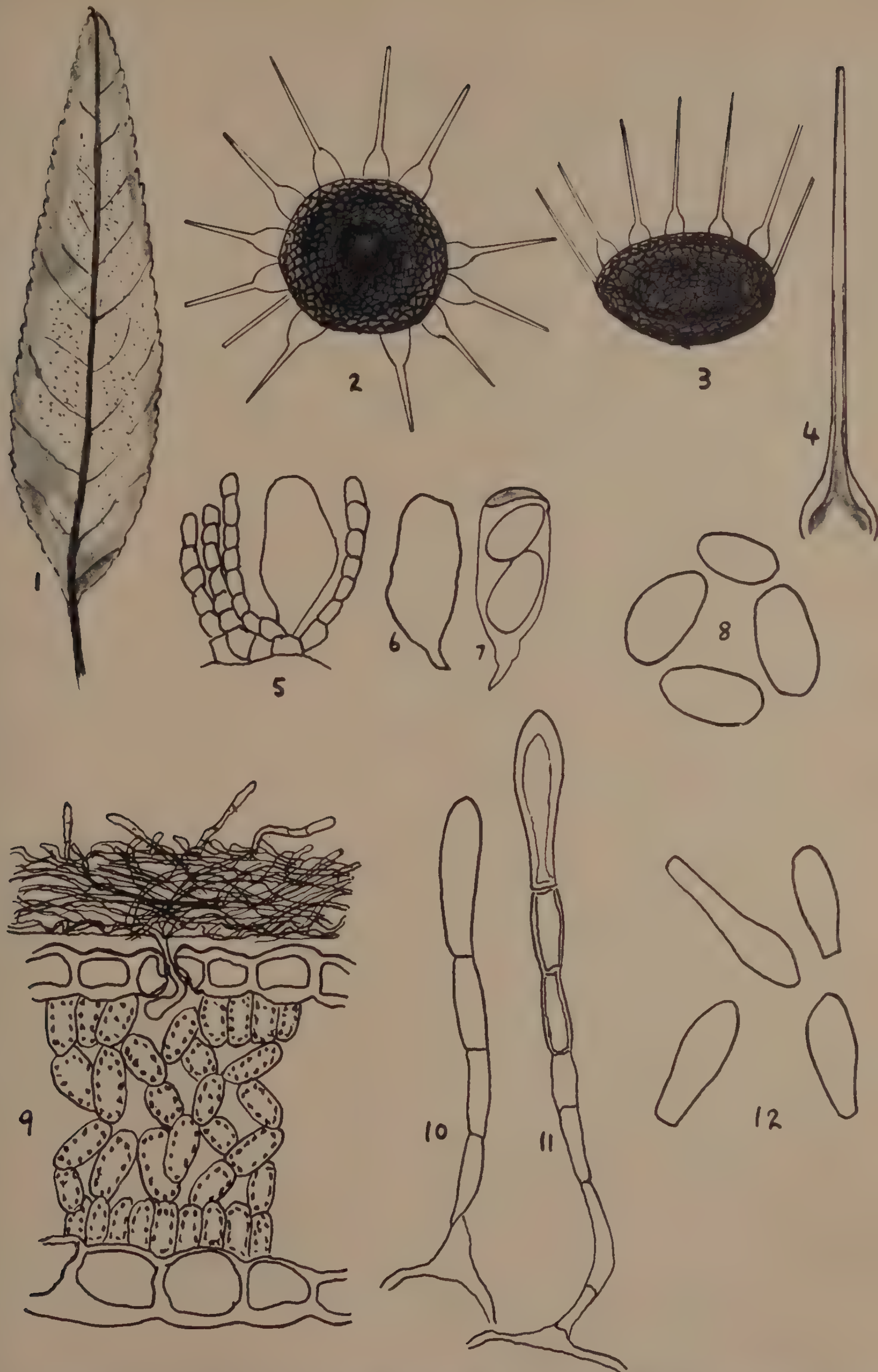
A species of *Phyllactinia* has been observed causing mildew of almonds (*Prunus Amygdalus*) in the Quetta Valley. The genus *Phyllactinia* has been recorded on a large number of hosts all over the world. In India Butler [1931] reported the occurrence of this fungus (*P. Corylea* Pers. Karst. var. *subspiralis*) on *Indigofera gerardiana*, *Juglans regia*, *Morus alba*, *Morus* sp., *Pyrus communis*, *P. Pashia* and *Dalbergia sissoo*. As far as the author is aware, hitherto, no species of *Phyllactinia* has been reported occurring on almond (*Prunus Amygdalus*), and this is probably the first record of *Phyllactinia* on this host.

Symptoms

The fungus causes mildew of leaves and young twigs. The disease makes its first appearance in midsummer (June and July) in the form of whitish cobwebby growth on the under-side of the leaves. This is due to the presence of mycelia and conidia of *Phyllactinia*. In August and September orange to dark brown perithecia appear as minute specks on this growth and continue till autumn leaf-fall. The disease is fairly common in certain orchards in the Quetta Valley but ordinarily does not do much damage. In cases of severe attack, however, the leaves become brittle and are slightly distorted ; occasionally parenchyma is destroyed and copper colourations appear on the leaves. The disease is most common on sweet almonds. The bitter almonds seem to be comparatively resistent to the disease.

Fungus

The genus *Phyllactinia* is known on a large number of hosts all over the world and several species are named. Salmon [1900] merged all the known species of *Phyllactinia* in *P. Corylea* (Pers.) Karst. Later in 1905, he recognized three varieties viz. *angulata*, *rigida* and *subspiralis*. Blumer [1933] revised the genus, raising the three varieties recognized by Salmon to specific rank. Amongst the known species, the *Phyllactinia* recorded on almond approaches



1. Almond leaf mildewed by *Phyllactinia Salmonii* Blumer (natural size); *2-3.* Perithecia of *Phyllactinia Salmonii* in different positions (× 100); *4.* Appendage of perithecium (× 900); *5.* Ascus with pseudoparaphyses (× 300); *6.* Young ascus (× 300); *7.* Ripe ascus with two ascospores (× 300); *8.* Ascospores (× 300); *9.* A section through a mildewed almond leaf, showing the formation of haustorium (× 220); *10-11.* Young conidiophores (× 600); *12.* Conidia (× 300).

Phyllactinia Salmonii Blumer, reported as occurring on *Paulownia imperialis* in Japan. A brief description of the fungus is given below :—

Hypophyllus, very rarely caulogenus, mycelium cobwebby evanescent or persistent, thin and effused ; forming whitish spots or coatings on the under-surface of almond leaves. Perithecia usually scattered, rarely gregarious, large, lenticular ; when ripe 200-350 microns in diameter, orange yellow when young, dark brown at maturity ; cells of the perithecial wall obscure, more or less polygonal, 13-24 microns wide ; true appendages 6-12, equatorial, rigid, straight, aseptate, hyaline, acicular, 220-350 microns long, with bulbous base about 40 microns wide ; asci indefinite, subcylindrical to ovate-oblong, average 120×32—40 microns, slightly pedicellate ; ascospores two, variable in size, average 56×28 microns ; conidiophores 240-300 microns long, 8-12 microns thick, hyaline, septate ; conidia unicellular, clavate, average 76-x 10-24 microns.

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NOTES

NOTIFICATION No. F.-46-20/38-A., DATED THE 6TH OF DECEMBER 1939, ISSUED BY THE GOVERNMENT OF INDIA, IN THE DEPARTMENT OF EDUCATION, HEALTH AND LANDS

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendments shall be made in the Order published with the notification of the Government of India in the Department of Education, Health and Lands, No. F. 320-35-A, dated the 20th July 1936, namely :—

I. In rule 12 of the said Order, after the words ' produced in India ', the words ' or in Burma ' shall be inserted.

II. In the Schedules annexed to the said Order

(1) for the Fourth Schedule the following Schedule shall be substituted, namely :—

Fourth Schedule (paragraph 12)

Certificate of origin for $\frac{\text{Indian}}{\text{Burman}}$ coffee beans or seeds

Name of consignor	Name of consignee	Gross weight	Number of packages	Mark of each package

Certified that the above consignment consists of raw coffee beans or seeds produced in India/Burma.

Signature of certifying authority.

No. of Railway Receipt or
No. of Bill of Lading.

Signature of Consignor.

(2) in the list of certifying authorities in the Fifth Schedule, after entry (*v*) the following entry shall be inserted, namely :—

' (*vi*) Customs Collector under the Government of Burma.'

(Sd.) J. D. TYSON,
Joint Secretary

NOTIFICATION No. F.-50-33/39-A., DATED THE 7TH OF DECEMBER 1939, ISSUED BY THE GOVERNMENT OF INDIA, IN THE DEPARTMENT OF EDUCATION, HEALTH AND LANDS

In exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Central Government is pleased to direct that the following further amendments shall be made in the Order published with the notification of the Government of India in the Department of Education, Health and Lands, No. F. 320/35-A, dated the 20th July, 1936, namely :—

In the said Order—

1. in paragraph 4 for the words ' potatoes and sugarcane ' the words ' potatoes, sugarcane and unmanufactured tobacco, either raw or cured,' shall be substituted,
2. paragraph 8 shall be renumbered as paragraph 8A, and after that paragraph as so renumbered the following paragraph shall be inserted, namely :—

   ' 8B. Unmanufactured tobacco, either raw or cured, shall not be imported into British India, unless, in addition to the general certificate required under Rule 5, it is accompanied by an official certificate, that it is free from *Ephestia elutelia* or that the pest does not exist in the country of origin.'

(Sd.) J. D. TYSON,

Joint Secretary

REVIEW

Plant hormones and their practical importance in horticulture. By H. L. Pearse. (*Technical Communication 12 of the Imperial Bureau of Horticulture and Plantation Crops, East Malling, Kent, England*) 1939, pp.88, bibl. 248. Price 3*s*. 6*d*.

INVESTIGATION of plant hormones and of their nature and properties still proceeds. Many of them have been isolated and chemically determined. Many now can be made synthetically, and thus made they are no less effective in stimulating growth. The history of this work has been told by Boysen-Jensen, Went and Thimann, Schlenker and others.

But whereas the academic botanist is primarily interested in how the plant grows, the practising horticulturist wants to know how he can increase or influence the growth made, and it is to him that the present memorandum should appeal most strongly.

Admittedly in the last few years articles on the propagation of particular plants from cuttings with the help of growth stimulants have been legion, but the man who spends most of his time tending plants has little opportunity to search the libraries and he will, therefore, be grateful to Dr Pearse for the tables in which nearly 1,000 instances are recorded of attempts made by different persons with varying success to root cuttings of plants of different plant species and variety with the help of named synthetic plant hormones. So far as is possible, the period and date of treatment, strength of solution, rooting medium, type of cutting, number of cuttings treated and number rooted are stated in each case.

In addition, he will find a clear account of the actual factors which affect root formation in cuttings, a review of published work on the practical use of synthetic plant hormones and notes on the practical methods found most useful by the author.

Unable to tear himself away from the fascinating subject, he will proceed with Dr Pearse to a consideration of the mechanism involved in induced root formation and note how increased efficiency of treatment may sometimes be realized by the use of such substances as vitamin B_1, carbohydrates, potassium permanganate, amino-acids, theelin and others.

He will learn of the surprising effects on plant growth brought to light by the curious scientist. Thus, hormone treatment definitely affects the germination of old or damaged seed, the growth of plants following treatment of seed, of the plants themselves or of their culture medium ; it also influences parthenocarpic development, fruit bud growth, fruit storage, framework control and rate of rooting in transplanted trees. Each one of these offers an interesting field of research.

And if he is still greedy for more, the comprehensive list of references shows him the way.

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